MAY 1958

MINING engineering

FREEPORT'S MOA BAY NICKEL PROJECT

Coming Events

May 8, AIME Utah Section, W. R. Hibbard, Jr., speaker; subject: Alloy Developments, Salt Lake City.

May 9, AIME Reno Subsection, Nevada Room, Mapes Hotel, Reno, Nev.

May 9-10, Dept. of Mining Engineering, Montana School of Mines and AIME, Mining Assn. of Montana, The Anaconda Co., Montana Soc. of Engineers, symposium on hydraulic emplacement of mine stope fill, Montana School of Mines, Butte, Mont.

May 9-11, AIME Uranium Section, Third Annual Uranium Symposium, Moab, Utah.

May 10, AIME Upper Peninsula Section, spring technical meeting, visit to Quincy Hoist, Houghton, Mich.

May 14, AIME San Francisco Section, speaker: A. B. Sabin; subject: Political Trends Affecting Mining in Indonesia; Engineers Club, San Francisco.

May 17, AIME El Paso Section, dinner-dance, El Paso, Texas.

May 19, EJC, local sponsor: Western Soc. of Engineers, Hotel Sherman, Chicago.

May 22-23, 34th annual conference, Lake Superior Mine Safety Council, Hotel Duluth, Duluth.

May 23, AIME Lehigh Valley Section, dinner-dance, Saucon Valley Country Club, Bethlehem.

May 24, AIME Adirondack Section, Jones & Laughlin trip, Star Lake, N. Y.

May 24, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

June 13, AIME Reno Subsection, Nevada Room, Hotel Mapes, Reno, Nev.

June 13-14, AIME Central Appalachian Section and SME Coal Division, joint meeting, Phoenix Hotel, Lexington, Ky.

June 22-25, Annual Convention of the Mine Inspectors' Inst. of America, Shirley-Savoy Hotel, Denver.

June 26, AIME Pennsylvania-Anthracite Section, summer meeting, Split Rock Lodge, White Haven, Pa.

June 28, AIME Adirondack Section, Gouverneur area zinc-talc operations trip, golf, Gouverneur, N. Y.

June 29-July 2, Rocky Mountain Coal Mining Inst., annual meeting, Hotel Colorado, Glenwood Springs, Colo.

July 3-5, Mining Soc. of Nova Scotia, annual meeting, Keltic Lodge, Ingonish, N.S., Canada.

July 26, AIME Adirondack Section, weekend with wives, Ottawa.

Aug. 23, AIME Adirondack Section, golf and speaker, Tupper Lake, N. Y.

Sept. 17-19, AIME Rocky Mountain Minerals Conference, Newhouse Hotel, Salt Lake City.

Sept. 22-25, American Mining Congress Mining Show, Civic Auditorium, San Francisco.

Sept. 27, AIME Adirondack Section, National Lead trip, Tahawus, N. Y.

Oct. 2-4, Annual Drilling Symposium, University of Minnesota, Minneapolis.

Oct. 9-10, AIME-ASME Solid Fuels Conference, Hotel Chamberlin, Old Point Comfort, Va.

Oct. 13-16, Soc. of Exploration Geophysicists, annual meeting, Gunter Hotel, San Antonio, Texas.

Oct. 23-25, AIME Mid-America Minerals Conference, Chase-Park Plaza Hotels, St. Louis.

Feb. 15-19 1959, AIME Annual Meeting, Sheraton-Palace, St. Francis, Sir Francis Drake Hotels, San Francisco.

MINING engineering

SOCIETY OF MINING ENGINEERS AIME

VOL. 10 NO. 5 — MAY 1958

COVER

Artist Herb McClure has chosen a path, palm-tree trimmed, to set the scene for the opening up and development of another of Cuba's nickel and cobalt deposits—deposits which will enhance the Free World's supply of these strategic metals. For the background and current status of this project, see page 563.

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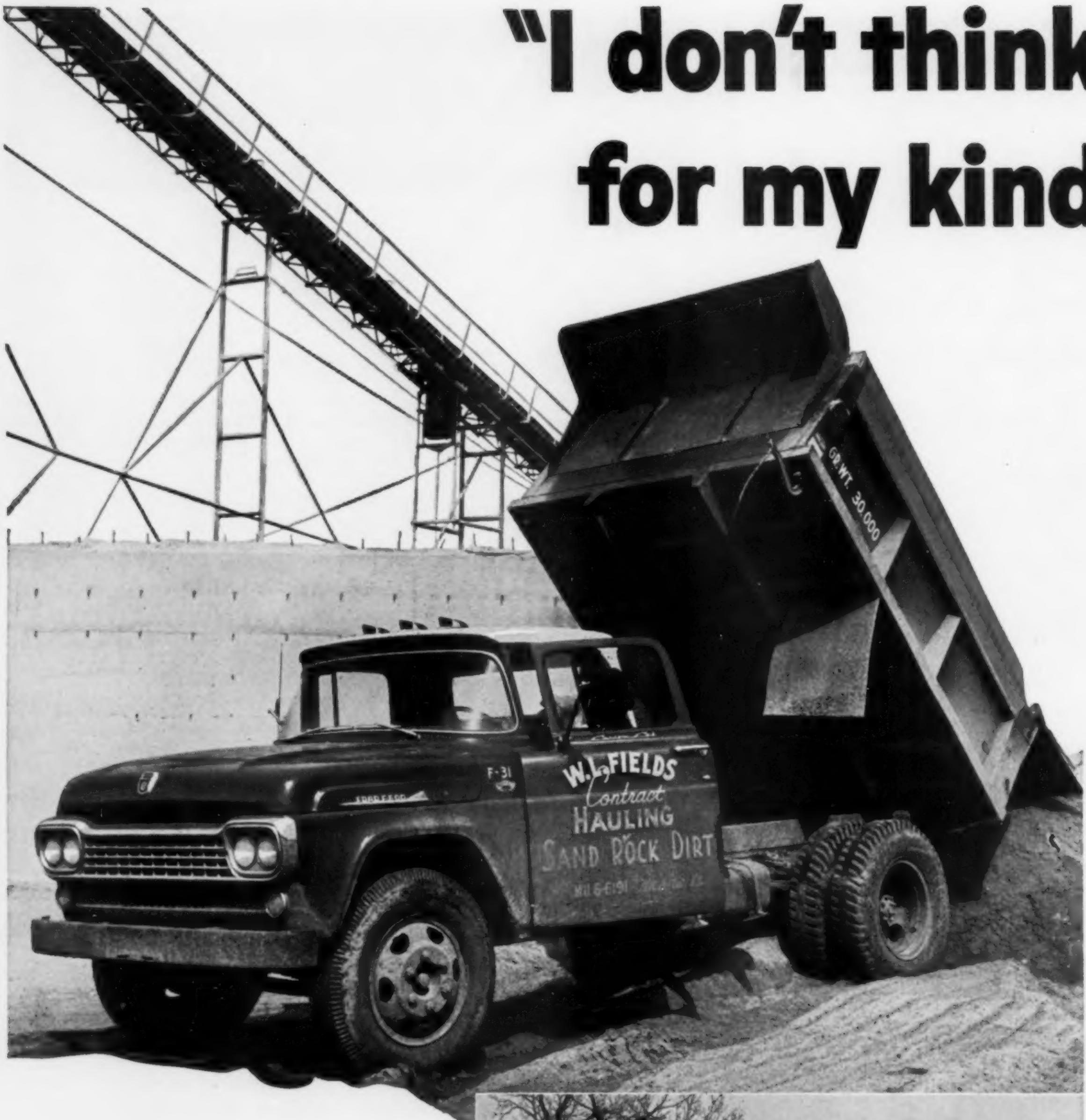
"I don't think for my kind



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THE following employment items are made available to AIME members on a nonprofit basis by the Engineering Societies Personnel Service, Inc. (Agency) operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

— MEN AVAILABLE —

Manager or Mine Superintendent, B.Sc. in mining engineering, age 40. Eighteen years experience mining engineering, exploration, mine plant construction, mine operation, management, and administration. Business and industrial management training. Experienced in personnel selection, labor and contractual negotiations, financing. Prefer North America. M-407.

Manager, B.Sc. in mining, age 44. Two years managing small uranium mine and 750-ton custom mill; eight years foreman and superintendent of 2000-ton gold mine in Central America; five years engineer, foreman, and assistant superintendent of 2000-ton gold mine in Canada; two years shift boss in 750-ton gold mine in Canada. Prefer western states or foreign. M-408.

Geologist, B.S. in geology, age 23, recent graduate (1957). Some experience demolition and pneumatic tools in Army Engineer Corps. Experienced maps and laboratory research. Location, immaterial. M-409.

Mining Engineer, B.S., age 32. Seven years experience all phases of active mine management; one year's experience heavy equipment sales. Prefer southwest. M-410.

Geological Engineer, B.S. in geological engineering, age 29, recent graduate. One-year experience in mine engineering. Prefer west, southwest, Mexico. M-411.

Geologist, B.S., age 32. Three and one half years experience in mining geology, mostly exploration, all phases. Prefer western U.S. M-1141-San Francisco.

Geologist, B.S. in geology, age 34. Seven years total experience; four years responsible experience in geological exploration and geochemistry, mostly for base metals and uranium. Have experience running field camp, minor background in geophysics. Prefer southeastern U. S. or foreign. M-1161-San Francisco.

Mining Engineer, English graduate. Twelve years experience in Africa and Asia. Previous employment has covered all aspects of mining but last five years has specialized in open cut mining; has held responsible positions; married; has aptitude for learning languages. Desires to join United States company operating overseas, location immaterial. Presently located Far East. M-412.

Executive Mining Engineer, with broad experience in executive and management positions, including production and exploration in base, precious metal, and uranium mining. Experienced with modern trackless and standard mining methods. Competent administrator and organizer. Exceptionally qualified for performance and leadership. Presently employed prominent mining company. Desires new position in mining or allied field. M-413.

Mineral Economist, age 29, B.S. and graduate work toward M.S. Nine months training in ore dressing and eight months experience in market research on finished products. Desires something connected with the procurement and marketing of mineral raw materials or with the evaluation of mineral-bearing properties. Graduate of the Army Language School in French. M-414.

Metallurgical Engineer, B.S. from Washington State University, age 31. Experience includes four years operation and development of mineral dressing processes, also four years in aluminum reduction industry, the latter largely in fume control and development work. Good health. Available now. Desires position in U.S. M-1175-San Francisco.

Mining Engineer, E.M. 1947, age 37. Experienced in supervision of underground base metal and nonmetallic mines by both standard and trackless methods. Engineering supervisory experience covering mine planning and development, layout of surface plant, shaft sinking. Married, children. Present position, mine superintendent. Prefer U.S. or foreign. M-699-San Francisco.

Geologist, B.S. in geology, age 24, 10 months. Graduated City College of New York in June 1954. Entered military service November 1954, as second lieutenant. Served in Europe from October 1955 to February 1958. Speaks French and Italian. Willing to travel. M-415.

Mining Engineer-Geologist, B.S. in mining engineering, age 46. Nineteen years experience including supervising exploration, development, and exploitation programs in mining operations. Six years foreign field experience on geological surveys and mineral examinations. Qualified as manager or engineer-geologist of exploration and mining operations. Prefer foreign, will consider domestic. Available immediately. M-416.

— POSITIONS OPEN —

Geologist/Geophysicist (#424), to 35. Minimum bachelor's degree in geology; master's degree desirable. Minimum of two years full-time geological or geological-geophysical employment. Will work directly with party chief in coordination and evaluation of gravimeter and magnetometer work and make geological interpretations of reflection seismic data, integrating both geology and geophysics in progress and final reports and in all sections and maps submitted. Salary, to $11,400 per year; allowances: single status, free board and lodging, plus equivalent of U.S. $54 monthly; married status, equivalent of $462 monthly after wife joins husband in field. If married, six months separation. Location, Far East. F6001.

Geologists, Development (#446-#450), graduate geologist, with good academic record, 25 to 40, with minimum of two years experience in petroleum geology with good working knowledge of electric log interpretation. Will develop and maintain current structural and isopachous maps and other illustrations to represent geologic conditions encountered; work in close cooperation with drilling, production, and reservoir engineers in preparing development plans, etc. Salary, $7,800 to $11,100 per year; allowances: single status, free board and lodging for employe, plus equivalent of U.S. $42 or U.S. $54 monthly; married status, equivalet of U.S. $362 or U.S. $462 monthly after wife joins husband in field. If married, six months separation. Location, Far East. F5999.

Mine Foreman for underground mine operations; B.S. in mining engineering and at least three years experience in supervisory position such as assistant mine foreman. Must have qualifications for future advancement. Three-year contract,

(Continued on page 533)

BOOKS

Current Safety Topics, 1957, Mining Industry, Transactions of the *National Safety Council,* 425 N. Michigan Ave., Chicago 11, Ill., 48 pp., 45¢ per pamphlet, $9.50 per set of 30, 1957. —Record of the sessions on mining held at the 1957 congress. Among the subjects covered are incentive award systems, use of diesel equipment in underground metal mines, use of ammonium nitrate commercial fertilizer as a blasting agent, and the safety programs of Bethlehem Steel Co., TCI, and The Anaconda Co.

The Lead Smelting Mills of the Yorkshire Dales, by Robert T. Clough, copies available from author, Willowdene, Utley, Keighley, Yorkshire, England, approx. 100 pp., approx. $5.75, June 1958.—A survey of the ruins of the lead mining and smelting industry of the Yorkshire Dales. Contains 40 plates on early lead mining techniques, the photos dating from 1865.

Soviet Bloc International Geophysical Year Information, PB 131632, *Office of Technical Services,* U. S. Dept. of Commerce, Washington 25, D. C., $10 for series, 1958-1959.—Weekly reports of Soviet bloc plans and endeavors in rockets and artificial earth satellites, upper atmosphere, meteorology, oceanography, latitude, seismology, glaciology, the Antarctic, and other subjects, contain information selected and translated from foreign-language publications. Series runs from Feb. 14, 1958 Publications-Distribution Section,

Keeping Coal Mines Dry, Standard M6.1, *American Standards Assn.,* 70 East 45th St., New York 17, N. Y., 75¢, 1955.—The standard contains recommended practices for draining mines and abandoned workings. Sponsored by USBM, the document poses solutions to problems encountered in selecting proper pumps, storing mine water, and in avoiding pollution of streams used as drainage carriers.

Difficulties Encountered in Smelting in the Lead Blast Furnace by R. W. Ruddle, *The Institution of Mining and Metallurgy,* 44 Portland Place, London W. 1, England, approx. $1.20, 56 pp., 1957.—A critical study of the work of Oldright and Miller in 16 reports of USBM published between 1929 and 1934, the work is divided into three parts. The first contains information on blast furnace operating conditions at Tooele, Kellogg, and Trail, the second is on formation of accretions at these smelters, and the third deals with the factors governing the lead contents of the slags.

F B I Register 1958, published for Federation of British Industries by

Books

(Continued from page 532)

Kelly's Directories Ltd. and *Iliffe & Sons Ltd.*, Books Dept., Dorset House, Stamford St., London S.E.1, England, 1138 pp., 42s post free (approximately $5.90), 1957.—Listing of products and services of over 7500 member firms under more than 5400 alphabetical headings. Contains classified buyers guide; details of organization, aims, activities of F B I in Great Britain and overseas; French, German, and Spanish sections; language glossaries; alphabetical address directory; trade association listing; brands and trade names; trade marks.

The Material Handling Handbook, edited by Harold A. Bolz and associate editor, George E. Hagemann, published by *Ronald Press* for *ASME*, 29 W. 39th St., New York 18, N. Y., 1750 pp., $20, 1958.—Results of project sponsored by ASME and American Material Handling Soc. covers progress made to date in materials handling. Amply illustrated with photographs, charts, tables, and diagrams, handbook is divided into 47 sections covering methods of analyzing handling problems; principles; procedures and techniques for effective operation and control; systems design and installation; integration of materials handling activities with the manufacturing processes; and design, selection, and classification of materials handling equipment. • • •

Dangerous Properties of Industrial Materials, by N. Irving Sax, *Reinhold Publishing Corp.*, 1467 pp., $22.50, 1957.—Revised and enlarged edition of *Handbook of Dangerous Materials* consists of over 8500 materials. Objective is to provide a single safety reference for safety and gives encyclopedic information on hazards of general chemicals and industrial material. Also contains information on toxicology and first aid, ventilation control, personnel protection and hygiene, atmospheric pollution, radiation hazards, industrial fire protection, storage and handling of hazardous materials, reactor safeguards, allergic diseases in industry, shipping regulations, and synonym index. • • •

Mining and Upgrading of Brown Coal in Europe—Developments and Prospects, sales No. 1957.II.E/Mim. 20, prepared by the Secretariat of the Economic Commission for Europe, obtained from Sales Section, *European Office of the United Nations*, Palais des Nations, Geneva, Switzerland, 41 pp. plus appendixes and tables, 50¢, 1957.—Covers production plans, resources, classification and qualities of European brown coals, technical progress in extraction, recent trends in uses.

Directory of Geological Material in North America, by J. V. Howell and A. I. Levorsen, second edition revised and enlarged with assistance of Robert H. Dott and Jane W. Wilds, *American Geological Inst.*, 2101 Constitution Ave. N.W., Washington 25, D. C., 208 pp., $3 (payment must accompany order), 1958.—Second edition contains list of sources of maps, reports, well records, libraries, museums, and other data available in each country of North America and each state and territory of the U. S.

Practical Prospecting, by Barry Storm, *Storm Publishing Assoc.*, Box 74, Inyokern, Calif., 60 pp., $2, 1957.—Intended for the nonprofessional, this field reference manual is aimed at prospectors, outdoorsmen, vacationers, and mineral hobbyists. It includes sections on geological prospecting criteria, electronic or finding devices, and mineral identification.

Technical Report Writing by James W. Souther, *John Wiley & Sons Inc.*, 70 pp., $2.95, 1957.—Textbook and reference manual provides information on how industrial reports are actually written, concentrating on the writing process. The author, assistant dean of engineering at the University of Washington, stresses the relation between the industrial function of the report and the final form it must take. • • •

Ideas, Inventions, and Patents—How to Develop and Protect Them by Robert A. Buckles, *John Wiley & Sons Inc.*, 275 pp., $5.75, 1957.—Simple, accurate, and readable statement of the principles and procedures for protection of ideas and inventions by a partner in the law firm of Watson, Leavenworth, Kelton, and Taggart. Gives the what, why, who, when, where, and how of property protection; and fundamental principles are illustrated by specific examples and illustrations, both historic and recent, in order to show good and poor practice. • • •

The Mining Act of Ontario (except Pt. VIIIO R.S.O. 1950, Chap. 236, compiled by *Dept. of Mines, Ontario*, and obtainable from Office of the Director of Publications, Dept. of Mines, Province of Ontario, Toronto 2, Ont., Canada, 226 pp. gratis, 1957.—Handbook covers the chapters pertaining to mining lands and the staking and recording of claims. Rules dealing with actual operation

(Continued on page 534)

Order directly from the publisher all books listed below except those marked • • • The books so marked (• • •) can be purchased through AIME, usually at a discount. Address Irene K. Sharp, Book Dept., AIME, 29 W. 39th St., New York 18, N. Y.

Personnel

(Continued from page 530)

with transportation both ways and salary while traveling. Location, South America. F5973(b).

Mining Engineer, B.S. in mining or geology, with practical experience in field of hydraulic mining and geology, to study brine production methods used on present wells and make recommendations to improve methods of operation. Through use of available geological data, must make recommendations for the drilling and development of additional wells. Salary, open; fringe benefits. Location, east. W5960.

Superintendent, age 30 to 40, to supervise production of Frasch sulfur mine operation. Must have engineering degree and at least ten years experience in all phases of sulfur production. Replies will be kept confidential. Location, Mexico. F4698S.

Safety Director, to organize safety program for uranium mining and milling operation of about 500 employes. Should have underground mining experience. Salary, open. Location, southwest. F6016.

Books

(Continued from page 533)

of mines are published separately. Diagrams show the correct method of staking claims under particular conditions. This edition has been revised to include amendments passed by the Legislature during the 1957 session. The volume is fully indexed.

Seventh Annual Drilling Symposium Proceedings, *School of Mines and Metallurgy* and the *Center for Continuation Study,* University of Minnesota, Minneapolis 14, Minn., $7.50, 170 pages, 1958.—The Proceedings cover the 7th Annual Symposium on Exploration Drilling held at the University of Minnesota in October 1957. The symposium was arranged to interest the industrial geologist, mining engineer, metallurgist, drilling contractor and manufacturer, civil engineer, and geophysicist. Five principal themes were highlighted—geophysical instrumentation of small bore holes, weighting and reliability of drill hole samples, small bore hole surveying, diamond drill bits, and air and mud as flushing media in exploration drilling.

The papers in the proceedings represent one of the most comprehensive coverages yet published on the adaptation of geophysics to small bore holes. The trend toward better core recovery and a more critical use of sampling results, an essential in the development of marginal low-grade deposits at depth, provided the reasons for a thorough discussion of these problems by a panel of specialists.

After opening the subject of small bore hole surveying and emphasizing the need for a small gyrascopic compass, the group was offered the first promise of a gyrascopic instrument that might be adapted to the surveying of 2-in.-diam holes. The special problems of coring unconsolidated materials and ice, together with the use of mud and air for a flushing medium instead of the conventional water, interested many attending the conference. Strides have been made in this area recently by men in both the soils mechanics field and the mineral industry.

Included on the program were papers on new and versatile drilling units and the most recent diamond drill equipment standards as set by the Diamond Core Drill Manufacturers Assn. and accepted in various parts of the world. • • •

State Publications

Ground-Water Resources of the Ladder Creek Area in Kansas, by Edward Bradley and Carlton R. Johnson, with a section on the **Chemical Quality of Water** by Robert A. Krieger, Bulletin 126, State Geological Survey of Kansas, *University of Kansas,* Lawrence, Kans., 190 pp., 11 plates, 21 figs., 14 tables, $1, 1957.

The Precambrian Rocks of Kansas, by O. C. Farquhar, Bulletin 127, Part 3, State Geological Survey of Kansas, *University of Kansas,* Lawrence, Kans., 68 pp., 9 plates, 4 figs., 75¢, 1957.

The Hydraulic Properties of the Ordovician Rocks at Pittsburg, Kansas, by G. J. Stramel, Bulletin 127, Part 5, State Geological Survey of Kansas, *University of Kansas,* Lawrence, Kans., 26 pp., 6 figs., 13 tables, 25¢, 1957.

Zonation of the Middle and Upper Ordovician Strata in Northwestern Georgia, by Arthur T. Allen and James G. Lester, Bulletin 66, The Geological Survey, *Georgia State Div. of Conservation,* Dept. of Mines, Mining, and Geology, Atlanta, Ga., 104 pp., 9 plates, 12 figs., 1957.

Geology and Ground-Water Resources of Torrance County, New Mexico, by R. E. Smith, Ground-Water Report 5, *State Bureau of Mines and Mineral Resources,* and *New Mexico Inst. of Mining & Technology,* Campus Station, Socorro, N. M., 180 pp., 16 tables, 7 figs., 5 plates, $3.50, 1957.

Geology and Mineral Resources of Dwyer Quadrangle, Grant, Luna, and Sierra Counties, New Mexico, by Wolfgang E. Elston, *State Bureau of Mines and Mineral Resources* and *New Mexico Inst. of Mining & Technology,* Campus Station, Socorro, N. M., 77 pp., 10 tables, 8 figs., 8 plates, $2.50, 1957.

Proceedings of the Illinois Mining Institute, 64th Annual Meeting, *Illinois Mining Institute,* George M. Wilson, Secretary, 102 Natural Resources Bldg., Urbana, Ill., 120 pp., 1956.

Symposium on Rock Mechanics, Vol. 51, No. 3, Quarterly, *Colorado School of Mines,* Golden, Colo., 239 pp., $2.00, 1956.

The Pelican Area, Palomas (Hermosa) District, Sierra County, New Mexico, by Richard H. Jahns, Bulletin 55 (Preliminary Map Issue), *State Bureau of Mines and Mineral Resources* and *New Mexico Inst. of Mining & Technology,* Campus Station, Socorro, N. M., 5 pp., 1 map, 75¢, 1957.

Geology of Questa Quadrangle, Taos County, New Mexico, by Philip F. McKinlay, Bulletin 53, *State Bureau of Mines and Mineral Resources* and *New Mexico Inst. of Mining & Technology,* Campus Station, Socorro, N. M., 19 pp., 1 map, 1 table, $1.25, 1957.

Reconnaissance Geologic Map of Lucra Spring Thirty-Minute Quadrangle, by Max E. Willard, Geologic Map 2, *State Bureau of Mines and Mineral Resources* and *New Mexico Inst. of Mining & Technology,* Campus Station, Socorro, N. M., 1 map, 50¢, 1957.

Permian Sedimentary Facies, Central Guadalupe Mountains, New Mexico, by Donald Wilkin Boyd, Bulletin 49, *State Bureau of Mines and Mineral Resources* and *New Mexico Inst. of Mining & Technology,* Campus Station, Socorro, N. M., 90 pp., 4 tables, 8 figs., 6 plates, $2.75, 1958.

Petrology of the Paleozoic Shales of Illinois, by Ralph E. Grim, William F. Bradley, and W. Arthur White, Report of Investigations 203, *Illinois State Geological Survey,* Urbana, Ill., 35 pp., 6 figs., 5 tables, 25¢, 1957.

Petrology and Sedimentation of the Pennsylvania Sediments in Southern Illinois: A Vertical Profile, by Paul Edwin Potter and Herbert D. Glass, Report of Investigations 204, *Illinois State Geological Survey,* Urbana, Ill., 57 pp., 8 plates, 19 figs., 13 tables, 25¢, 1958.

Pennsylvania Faunas of the Beardstown, Glasford, Havana, and Vermont Quadrangles, by Harold R. Wanless, Report of Investigations 205, *Illinois State Geological Survey,* Urbana, Ill., 59 pp., 2 figs., 4 tables, 25¢, 1958.

Studies of the Actinoceratida, I. The Ordovician Development of the Actinoceratida, With Notes on Actinoceroid Morphology and Ordovician Stratigraphy; II. *Macroloxoceras,* a Devonian Homeomorph of the Actinoceratida, by Rousseau H. Flower, Memoir 2, *State Bureau of Mines and Mineral Resources* and *New Mexico Inst. of Mining & Technology,* Campus Station, Socorro, N. M., 100 pp., 5 figs., 13 plates, $4.00, 1957.

Investigation of Lake Agassiz Clay Deposits, by Oscar E. Manz, Report of Investigation No. 27, *North Dakota Geological Survey,* Grand Forks, N. D., 34 pp., 3 figs., 6 tables, 75¢, 1956.

Geology of Tuscarawas County, by Raymond E. Lamborn, Bulletin 55, *Ohio Div. of Geological Survey,* Dept. of Natural Resources, Orton Hall, The Ohio State University, Columbus 10, Ohio, 257 pp., 4 figs., 3 maps, $3.00 (plus 9¢ tax in Ohio), 1956.

Geologic Map of Hillsboro Peak Thirty-Minute Quadrangle, by Frederick J. Kuellmer, Geologic Map 1, *State Bureau of Mines and Mineral Resources* and *New Mexico Inst. of Mining & Technology,* Campus Station, Socorro, N. M., 1 map, 50¢, 1956.

U. S. Geological Survey

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U. S. Government Printing Office
Washington 25, D. C.

Bulletin 1019-H Selected Annotated Bibliography of High-Grade Silica of the United States and Canada Through December 1954, 25¢.

Bulletin 1067 An Introduction to the Geology and Mineral Resources of the Continental Shelves of the Americas, 75¢.

U. S. Bureau of Mines

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RI 5372 Determination of the Average Effective Valence State of Titanium in Sodium Chloride.

RI 5374 Carbonizing Properties of Westmoreland County, Pa., Coals.

IC 7804 Report of Research and Technologic Work in Explosives, Explosions, and Flames, Fiscal Years 1953 and 1954.

IC 7808 Auxiliary and Supplemental Mine Rescue Equipment.

IC 7813 Mechanical Mining in Some Bituminous-Coal Mines.

RI 5373 Tin-Bearing Placer Deposits Near Tofty, Hot Springs District, Central Alaska.

RI 5377 Laboratory Concentration of Chromite Ores, Red Mountain District, Kenai Peninsula, Alaska.

RI 5378 X-Ray Emission Spectrographic Analysis of Bastnaesite Rare Earths.

RI 5379 Clay Minerals and Permabilities of Appalachian Oil Sands.

RI 5380 Design and Testing of Bureau of Mines Pneumatic Coal Planer.

Minerals Yearbook 1954, Vol. I, Metals and Minerals (Except Fuels), prepared by Div. of Minerals Staff, *U. S. Bureau of Mines,* available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 1427 pp., $4.50, 1958.—Data includes that collected by USBM and that for the 1954 Census of Minerals Industry. This volume includes chapters on mineral commodities, both metals and nonmetals, but exclusive of fuels. Also included are a chapter reviewing the mineral industries covered, a statistical summary, and chapters on mining technology, metallurgical technology, and employment and injuries.

Minerals Yearbook 1954, Vol. III, Area Reports, prepared by Field Staff, *U. S. Bureau of Mines,* available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 1187 pp., $4, 1957.—Data includes that collected by USBM and that for the 1954 Census of the Minerals Industry. Vol. III contains chapters covering each of the 48 states, Alaska, Hawaii, U. S. island possessions in the Pacific Ocean, Puerto Rico, Canal Zone, and U. S. island possessions in the Caribbean Sea. It also contains statistical summary and employment-injury data chapters. Indexing in this volume has been suspended, since the parallel structure of the area chapters appears to afford sufficient guidance to information.

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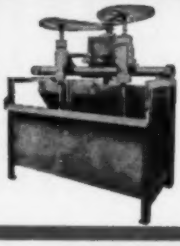

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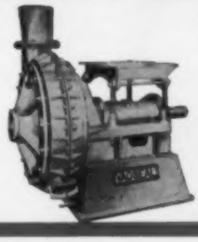
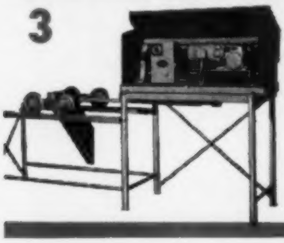


VACSEAL PUMP

A complete line of solids handling and acid pumps. Sizes 1½" to 8".

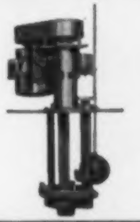
3



GEARY-JENNINGS SAMPLER

Accurate, automatic samples of practically all types of material.

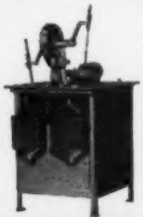
4



GALIGHER SUMP PUMP

Available in standard or acid-proof construction. No seals, packing or submerged bearings. Sizes 1½" and 2½"—capacities 10 to 250 GPM.

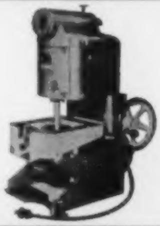
5



GEARY REAGENT FEEDER

Designed to feed accurately all types of liquids and solids in suspension. Capacities range from 25 cc. to 10,400 c.c. per min. per cup.

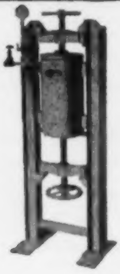
6



LABORATORY AGITAIR®

500, 1000, 2000 gram employing the same principle of flotation as the world-famous commercial AGITAIR®.

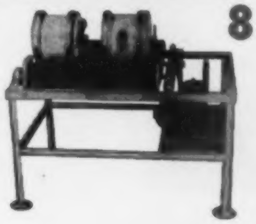
7



LABORATORY PRESSURE FILTER

Simple, rugged design, 3½ gal. capacity. Operates at pressures up to 125 psi.

8



LABORATORY BALL MILLS

Designed for 1 or more mills with grinding capacity of 1000 to 2500 gram charge per mill.

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AP-503

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GALIGHER PRODUCTS: AGITAIR® Flotation Machine, VACSEAL Pump, Geary-Jennings Sampler, Acid-proof Sump Pump, Geary Reagent Feeder, Laboratory AGITAIR® Flotation Machine, Laboratory Pressure Filter, Laboratory Ball Mill, Rubber Lined and Covered Products, Plastic Fabrication.

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Manufacturers News

News
Equipment
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Percussive Drills

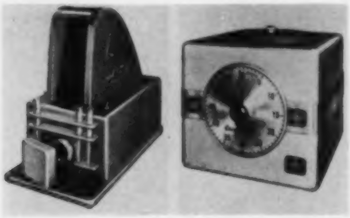
Three new drills for medium and deep-hole operations have been introduced by *Chicago Pneumatic Tool Co.* Standard rotation CP-400 drills 3-in. holes to 25 ft. Both other models have standard-neutral-reverse rotation. The 4-in. CP-400 DR will bore 2½-in. holes to 50 ft and the 4½-in. CP-450DR can sink 3-in. holes to 75 ft. **Circle No. 1.**

Fine Grinding

Sturtevant Mill Co. has been successful in grinding particles to ½μ in modified Micronizer fluid energy mills. Units force violent impact of particles with jets of compressed air or steam, give pulverization without attritional heat. Sturtevant makes Micronizers in sizes from 2 to 36-in. diam. **Circle No. 2.**

Particle Size Analyzer

Size distribution of small particles can be measured at low cost with a new analyzer by *Mine Safety Appliances Co.* Design is for particles



between 0.1 and 40μ and the system includes centrifuge tubes, feeding chamber, optical tube projector, and one or more special centrifuges. **Circle No. 3.**

Side Dump Bucket

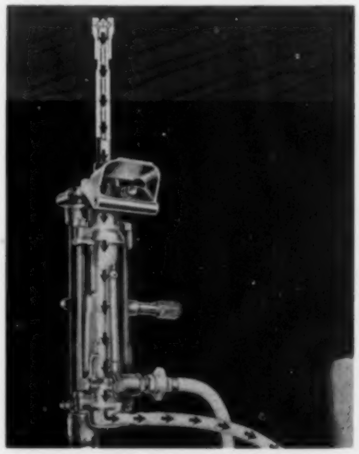
Caterpillar now has a side dump bucket for the company's largest Traxcavator, the No. 977. Attachment has 2¼-cu yd capacity. **Circle No. 4.**

Compressor

Model 25S2, a new 25-hp stationary air compressor by *Le Roi Div.*, Westinghouse Air Brake Co., is rated for continuous duty at 175 psi. Electric motor-driven, air-cooled unit displaces 120 cfm. **Circle No. 5.**

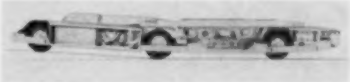
Dustless Stoper

Vacujet, a new rock drill by *Ingersoll-Rand*, eliminates dust in stoping operations by sucking cuttings down through the drill and discharging them to a container about 25 ft away. One-inch air hose can be used to convey material—expensive vacuum hose is unnecessary. Large passage through special drill steel allows full-throttle drilling. **Circle No. 6.**



Low-Seam Shuttle Car

Joy Mfg. Co. says its new six-wheeled shuttle car has more than double the capacity of existing cars of similar height. Success lies with the use of smaller wheels, extra



large fixed height conveyor 6 ft wide and 27 ft long. Car is hinged near middle traction wheels, steered by four corner wheels. Labeled 18-SC, the car is 27 ft long, 11 ft 6 in. wide, 27 in. high. **Circle No. 7.**

Screen Cloth Tool

Vibrating screen cloth can be changed in half the time needed with conventional nuts and bolts with a new device by *Hewitt-Robins Inc.* Outfit costs $3.65, consists of special slotted bolt and wedge, with retaining washer and swivel washer. A few hammer blows set or remove it. **Circle No. 8.**

New Payloader

Model H-25, a new Payloader by *Frank G. Hough Co.*, is first rubber-tired, front-end loader with rated carrying capacity of 2500 lb. Unit has

two-speed, full-reversing power-shift transmission, triple air cleaning system, choice of engines, choice of buckets. **Circle No. 9.**

Rear Dump

Euclid's new model R-27 rear dump takes a rated load of 27 tons in either a standard or optional quarry type body. Dumper is

equipped with either 300-hp Detroit diesel or 335-hp Cummins engine, Allison Torqmatic drive. Top loaded speed is 34 mph. **Circle No. 10.**

Nitrate Packer

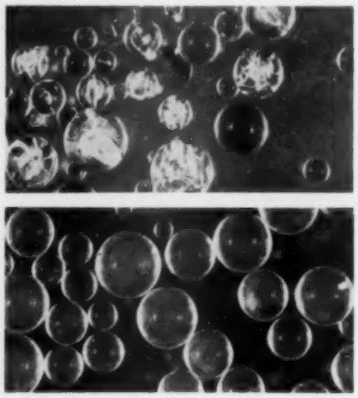
United Electric Coal Co. is using a *Bemis Bro. Bag Co.* Packer-Ette bag filling machine to pack its ammonium nitrate explosives at the mine level. Machine weighs material, fills bag or can in 8 sec. United plans to install another soon. **Circle No. 11.**

Better Bin Flow

Without moving parts or vibrating mechanism, the Easy-Flo bin device by *Bituminous Coal Research Inc.* speeds flow of coal, other bulk solids. Double-cone arrangement inside keeps material unpacked. Unit is said to provide problem-free handling of ¼x0-in. coal with up to 15 pct surface moisture, reliable flow with sizes up to 3 in. Device has 7000 lb per min gravity feed capacity. **Circle No. 12.**

Cation Exchange Resin

Dowex 50W, a new development by *Dow Chemical Co.*, is a cation exchange resin which gives increased physical stability without decrease in ion exchange capacity. The white resin comprises a styrene-divinylbenzene matrix, to which are attached ionizable groups of nuclear sulfonic acid. This structure gives maximum resistance to oxidation, reduction, mechanical wear, and breakage, and is insoluble in all common solvents. Compare photo of standard beads (upper) showing life-shortening cracks with that of stress-free material (lower). **Circle No. 13.**



Placing Concrete

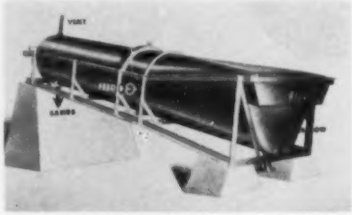
Concrete buggies and other distributing equipment are unnecessary when concrete is placed by one of two new units by *Air Placement Eqpt. Co.* Unit shown, model CP-10, handles 10 cu ft of concrete per charge and delivers it via pipeline, vertically if necessary. Model CP-15 has 15-cu ft capacity. **Circle No. 14.**

Vulcanizing Press

A new molding press for reinsulating and rejacketing rubber, synthetic, and thermoplastic covered cables is offered by *Joy Mfg. Co.* Standard cable types and sizes are accommodated by interchangeable aluminum molds. Weight, less molds, about 85 lb. **Circle No. 15.**

Vapor-Tight Classifier

Denver Eqpt. Co. has a new vapor-tight spiral classifier designed to retain pressures to 15 psi. Available in size range 6 to 60-in. diam, the classifier is fitted with cover, pressure tight feed opening and overflow discharge, and sealed sand discharge



housing. Can be supplied in corrosion-proof construction. **Circle No. 16.**

Lower Drilling Costs

Chicago Pneumatic Tool Co. says blast-hole drilling costs are being cut by up to 35 pct by users of rotary air blast bits. Company offers two types: Standard, which employs center air blast to flush cuttings; and Jet, which has an additional three air ports for extreme depths or difficult conditions. **Circle No. 17.**

News & Notes

Kenworth Motor Truck Div. of Pacific Car & Foundry Co. has purchased almost all assets of *Dart Truck Co.*, plans to continue Dart line in a Kansas City, Mo., plant to be built by new *KW-Dart Truck Co.* Kenworth rock and ore mover production will transfer to Kansas City—other units will remain in Seattle, Vancouver, B. C. . .*American Cyanamid* has formed a combination unit to be called the Explosives & Mining Chemicals Dept. . .*Mine Safety Appliances Co.* has purchased controlling interest in Berlin firm, Auer Co. Inc., a leading manufacturer of safety equipment. . .*Le Roi* has sold the assets of its engine business to *Waukesha Motor Co.*, will concentrate on air compressors, tools. . . . *Caterpillar Tractor Co.* has used radioisotopes in its research since 1954 . . . .*Southwestern Engineering Co.* has moved its Separator Div. into new and expanded facilities at 4501 Sante Fe Ave., Los Angeles. . . . Mexico's first triple superphosphate plant will be designed and engineered by *Dorr-Oliver Inc.* . . . Pittsburgh firm, *National Mine Service Co.* has acquired the Greensburg Machine Co.

ALUMINUM SHEETS & PLATES: A new 320-page Kaiser book supplies the answers to questions on the use of aluminum sheet and plate. Included are numerous tables, comprehensive index. The "Kaiser Aluminum Sheet & Plate Products Information Book" may be requested—only on company letterhead—from Technical Editor, *Kaiser Aluminum & Chemical Sales Inc.*, 919 North Michigan Ave., Chicago 11, Ill.

(21) REAGENT FEEDERS: A new 4-page bulletin from *Denver Eqpt. Co.* gives details on the model 12-A wet reagent feeders and cone type dry reagent feeders. Wet feeder operates continuously at up to 2250 cu cm per min. Dry feeder is adjusted for accuracy by three simple controls: speed, depth of bed, amount of discharge cut.

(22) UPGRADING SILICA SANDS: Bulletin G-14 from *Armour Chemical Div.* gives four examples of production of quality silica sand by flotation with anionic and cationic reagents. Chemical cost estimates range from 9 to 40¢ per ton of ore treated.

(23) WET CLASSIFICATION: *Hardinge Co. Inc.* has a revised catalog on classifiers, Hydro-Separators, washers, and heavy media separators—bulletin 39-C. Combined grinding and wet classifying flow sheets are included.

(24) CLOSED CIRCUIT TV: Vicon television systems for industrial use are offered by *Insul-8-Corp.* in both manual and remote control models. Three units required: camera, camera control, and monitor.

(25) ROTARY DRILL: Model M-7WA rotary drill by *Davey Compressor Co.* features an open faced jackknife mast that facilitates use of extra wide break-out tongs and results in a 96-in. working area. Instant changeover from air to mud drilling is possible through system of by-pass valves.

Free Literature

(26) JET-PIERCING: *Linde Co.*, div. of Union Carbide Corp., offers a 12-page booklet on the use of the jet-piercing process in blastholing taconites, making channels in dimension stone quarries, and shaping and finishing stone. Form 1113, "Application of the Rocket Jet to Mining and Quarrying," also has data on burner design, heat transfer, and flame geometry.

(27) TRACTOR: A new 12-page booklet from *Caterpillar Tractor Co.* cites case histories of the DW-21

tractor in action. Covered are engineering features which permit maximum scraper loading efficiency.

(28) WIRE ROPE LUBRICANT: A free 16-oz sample can of a wire rope spray lubricant is offered by *Whitmore Mfg. Co.* Packaged in an aerosol container, the non-gumming lubricant penetrates to the rope core, minimizing internal friction and increasing rope life.

(29) CENTRIFUGAL PUMP: *Galigher Co.* bulletin PB56 supplies details on the Vacseal solids-handling and acid pumps. Capacity ranges from 10 to 3000 gpm. Models can handle heads up to 150 ft and suction lifts up to 12 ft.

(30) ROCK BITS: A new 6-page bulletin describing a line of one-use drill bits is available from *Le Roi Div.*, Westinghouse Air Brake Co. New bulletin RD29 shows construction, preparation of rod shanks, lists specifications.

(31) IMPACT CRUSHER: Cuber Junior—designed for primary and secondary crushing—is a single-rotor unit by *Kennedy Van Saun Mfg. & Eng. Corp.* Details available in bulletin D-1006. Specifications include capacities to 250 tph in closed circuit, with connected horsepowers from 75 to 150.

(32) VIBRATORY FEEDER: *Syntron Co.* offers a catalog on the new model F-115 feeder which feeds up to 6 tph from a flat pan trough. Electromagnetic drive assures free flow of hard-to-handle material.

(33) STRIPPING: A field report from *Sauerman Bros. Inc.* details "Strip Mining with Tower Excavators," and shows lignite operation of Truax-Traer at Velva, N. D.

(34) BLOWERS & GAS PUMPS: Increased capacity ratings have been announced by *Roots-Connersville Blower*, div. of Dresser Industries Inc., for the full line of type AF Rotary Positive blowers and type XA Rotary Positive gas pumps. Details in bulletin AF-XA-157.

(35) END SUCTION PUMPS: *Aurora Pump Div.*, New York Air Brake Co., describes new end suction type BC general purpose pumps in 8-page bulletin 119-C.

(36) SLURRY PUMP: Bulletin 188 from *Morris Machine Works* describes capacities and applications of the new BA medium-range, high speed slurry pump. Designed to handle suspensions of sand, coal, crystals, silt, and chemical process slurries, the pump is available in cast iron, Ni-hard, or stainless, and features a renewable suction liner and semi-open impeller.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

5

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after August 15, 1958—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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Company____________________

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51	52	53	54	55	56	57	58	59	60
61	62	63	64						

Students should write direct to manufacturer.

(37) BULK HANDLING: Catalog 5712 from *Syntron* Co. contains 60 pages of vibratory bulk materials handling equipment and other products. Included are vibrators, car rappers, flow control valves, feeders, screens.

(38) ROPE HAZARD: *Leschen Wire Rope Div.*, H. K. Porter Co. Inc., has a 4-page folder on the dangers of crushed wire rope. Major causes, including overloading, quick starts, wrong sheave sizes, and others, are described with suggestions for decreasing or eliminating them.

(39) CRAWLER: TD-14, an *International Harvester* Co. crawler tractor equipped with the 4-in-1 Drott skid shovel, is detailed in a new 16-page booklet. Versatile unit is featured with nine optional attachments.

(40) VIBRATING SCREENS: *Simplicity Engineering* Co. offers a new catalog on gyrating, Simpli-Flo, and horizontal vibrating screens. Intended for those in the coal mining and aggregate industries, the catalog covers Simplicity equipment such as the Grizzly Feeder, Os-A-Veyor feeders, aggregate screens for scalping, sizing, and dewatering. The 30-page catalog (571) also contains complete dimensions and screen capacities.

(41) NICKEL CADMIUM BATTERIES: An 8-page bulletin covering rechargeable general purpose nickel cadmium batteries is offered by *Gulton Industries Inc.* VO-Series includes batteries with nominal voltages in multiples of 1.2 v, with rated capacities from 0.1 to 160 amp-hr. Units are claimed to outlast conventional batteries by up to 20 times.

A 24-pp. catalog titled *Material Handling Films* has been issued by the Material Handling Inst. Inc. The catalog lists over 60 material handling education and training films, all of which are offered for loan, free of charge, by the member company of the Institute. The films, which cover a wide variety of material handling subjects, are grouped into 12 major categories. Under each film listing is a brief description, total running time, ordering information, and whether the film is in color or black and white. The catalog may be obtained free from *Material Handling Inst. Inc., Educational Div., 1 Gateway Center, Pittsburgh 22, Pa.*

New Films

Caterpillar Tractor Co. shows the operation of *The No. 933 Traxcavator* in a 12-min sound and color motion picture. Illustrating how this versatile machine performs on a wide variety of jobs, the film also explains why an increasing number of users—industrial, governmental, and others—are relying on machines to increase efficiency and reduce costs. The film also demonstrates uses of the attachments of No. 933: the bulldozer blade, light materials handling bucket, and other attachments which tailor the machine to special applications. Showing of the film may be arranged through the nearest Caterpillar dealer or by writing *Caterpillar Tractor Co., Peoria, Ill.*

Pure and Simple, a 19-min motion picture released by Link-Belt Co., outlines practical solutions to the problems of industrial waste and water conservation. Ways which industry, user of over 80 billion gal of water daily, can conserve this natural resource by combatting pollution, salvaging valuable byproducts, recirculating water, and treating sewage wastes are highlighted in the film. Specialized equipment is shown in action and details of how various systems work are dramatized by animation. Free showing is available upon request by writing on company or organization letterhead to the *Public Relations Dept., Link-Belt Co., Prudential Plaza, Chicago 1, Ill.*

The Big Z, a film produced by the Ontario Dept. of Mines, Canadian Province of Ontario, in cooperation with a number of interested mining companies and directed by Jack Chisholm and produced by Showcase Film Productions, depicts the story of the discovery and development of the Blind River uranium area. The film derives its title from the shape of the deposition of the uranium-bearing conglomerate in the area. It traces—from the geological age two billion years ago that resulted in the deposit—the evolution of the area which resulted in the discovery of the radioactive element, the rush for staking claims, and the development of the area to its present active state. Truly Canadian in both subject matter and production, the film was produced by the Dept. of Mines in association with Rio Tinto Mining Co. of Canada Ltd., Stanley Uranium Mines Ltd., and Joy Manufacturing Co. The picture is available for free loan to any interested groups by contacting the *Film Library, Ontario Department of Mines, Toronto, Canada.*

The Hyster Hydraulic Backhoe, a new 11½-min 16-mm sound color film, has been produced by the Hyster Co. and illustrates the design and performance features of the Backhoe as a utility excavating machine for solving digging problems encountered by contractors, gas companies, and public works departments. Several of the performance features illustrated are the 240° swing arc which increases job accessibility in spite of obstacles, the short-cycle simultaneous lift and swing action to reduce cycle time to a minimum, and the tractor mounting method which maintains full bulldozing capacity, maneuverability, and tractive effort. All the features of the machine are demonstrated in actual performance. The film is available for loan, or a print for sale at $66.50 can be obtained, by writing the local Caterpillar-Hyster dealer or *Hyster Co., 2902 N.E. Clackamas St., Portland 8, Ore.*, or *1800 North Adams St., Peoria 1, Ill.* Also available for distribution at the showing are copies of the narration and a 16-page, 3-colored catalog on the D4 Backhoe.

Three Legged Islands, a new 18-min 16-mm sound color movie is available from R. G. LeTourneau Inc. The film shows the construction of three off-shore platforms at Vicksburg, Miss., and the operation of two others. The "Scorpion" recently set a time record for relocation activity in the Gulf of Mexico and the "Vinegarroon" weathered hurricane Audrey with virtually no damage. Both of these LeTourneau-built off-shore platforms are depicted. The movie is available for showing to petroleum groups without charge by writing to: *R. G. LeTourneau Inc., 2399 South MacArthur, Longview, Texas.*

Aluminum Price Takes A Bump

In a sudden move in late March, Aluminium Ltd., top Canadian producer, announced it would reduce its prices of aluminum ingots about 2¢ a pound on April 1. Company pointed out that important segments of the industry were idle and new application encouragement and a better competitive position were needed. Announcement was swiftly followed with 2¢ slash by leading American producers. Cut was first since 1941—climb had been fairly steady since 1948.

Zinc Stockpiling Ended, Lead to Follow

A zinc price support—Government acceptance of domestic metal for stockpile—has ended with the delivery of a final consignment at the end of April. Lead acquisitions are not expected to continue after July 1. End of purchases is expected to add new vigor to demands for tariff protection.

Steel, Auto Firms Put Money into Moa Bay Project

More than $25 million has been contributed to the Cuban nickel-cobalt project of Freeport Sulphur Co. by six nickel-consuming steel and automobile companies. All have entered into contracts to buy "substantial amounts of nickel under certain conditions and under which they have the right to purchase additional amounts." Freeport President L. M. Williams stated "the participation by these large nickel consumers in the financing of our project is a clear indication of the need for additional nickel productive capacity." (See pages 563 to 565 for the story of the Moa Bay-Port Nickel project.)

Chilean Copper Project Financed

$6.4 million has been raised for development of a copper mine and smelter owned by Empresa Minera de Mantos Blancos S. A., a Chilean company, by three private investment firms and the International Finance Corp. Mill and refinery—already under construction—will process 2000 tpd of ore, producing some 25 million lb of refined metal yearly. Two companies of the Hochschild group will supply the remainder of the $12.8 million required for financing. Properties are 45 miles northeast of Antofagasta, largest city and port in northern Chile.

Another Coal Mine-and-Plant Project

Pittsburgh Consolidation Coal Co. will open its 3 million tons per year mine, the Loveridge in West Virginia, some time this spring—with an important tie-in. The coal produced, after processing to remove valuable chemicals, will be used as char—a fine coke-like residue—to fire the boilers of the Ohio Power Co.'s 675,000-kwh Kammer station. This station, in turn, will supply power for an aluminum reduction plant being built a short distance down the Ohio River by Ormet Corp. Newly developed boilers by Babcock & Wilcox Co. permit use of the low-volatile char for industrial fuel. . . . Another closely linked operation will be employed by the Cameo Steam-Electric station near Grand Junction, Colo., which will feed its boilers with coal from the nearby Cameo coal mine—via belt conveyor.

(Continued on following page)

Reynolds Takes Potential Coal Power Site

An additional 7300 acres in the Lake DeSmet, Wyo., coal area have been acquired by Reynolds Mining Corp. as a possible future power site for the aluminum reduction facilities of Reynolds Metals Co. Acreage is adjacent to coal deposits in which seam averages more than 150 ft thick. No plans for plant construction to date.

AEC Shifts to Limited Upstep of U_3O_8 Buying

In a reversal of its October 1957 announcement, the AEC says it intends a limited expansion of domestic uranium procurement. Total domestic milling capacity will be increased by about 3000 tpd of ore, and annual concentrate production by about 2500 tons of U_3O_8. Action resulted from market study initiated after complaints from mining firms in some areas that, after heavy spending on development, they were cut off with no ore market.

New Iron Powder Plant

Alan Wood Steel Co.'s 50-tpd iron powder plant, scheduled for early 1959 production, will be the first commercial unit to use a *fluid bed* process for direct reduction of iron ore. Process involves suspending particles of concentrate in a stream of hot hydrogen gas until reduction is completed. Plant will be adjacent to company steel works in Conshohocken, Pa.—will use available coke oven gas for fuel and as a source of hydrogen.

Iron—Ore Stocks Up . . . Taconite . . . Newfoundland

Steel market and other troubles are causing ore stocks to climb rapidly—blast furnace use fell off sharply early this year over last. Imports are higher, too, so much so that talk of quotas and tariffs is growing stronger. Great Lakes ore carriers are getting off to a late start . . . Reserve Mining Co. will deliver through Oglebay Norton Co. the 1.5 million tons of taconite pellets expected from its Silver Bay plant this year. . . . Newfoundland has sold its share of the government-initiated Newfoundland & Labrador Corp. (Nalco) to Canadian Javelin for account of that company and Wabush Iron Co. Ltd. Concessions—covering 24,000 sq miles—will be explored "promptly and actively." Large iron reserves have already been proven.

Surprise Geiger Counter Claim Decision

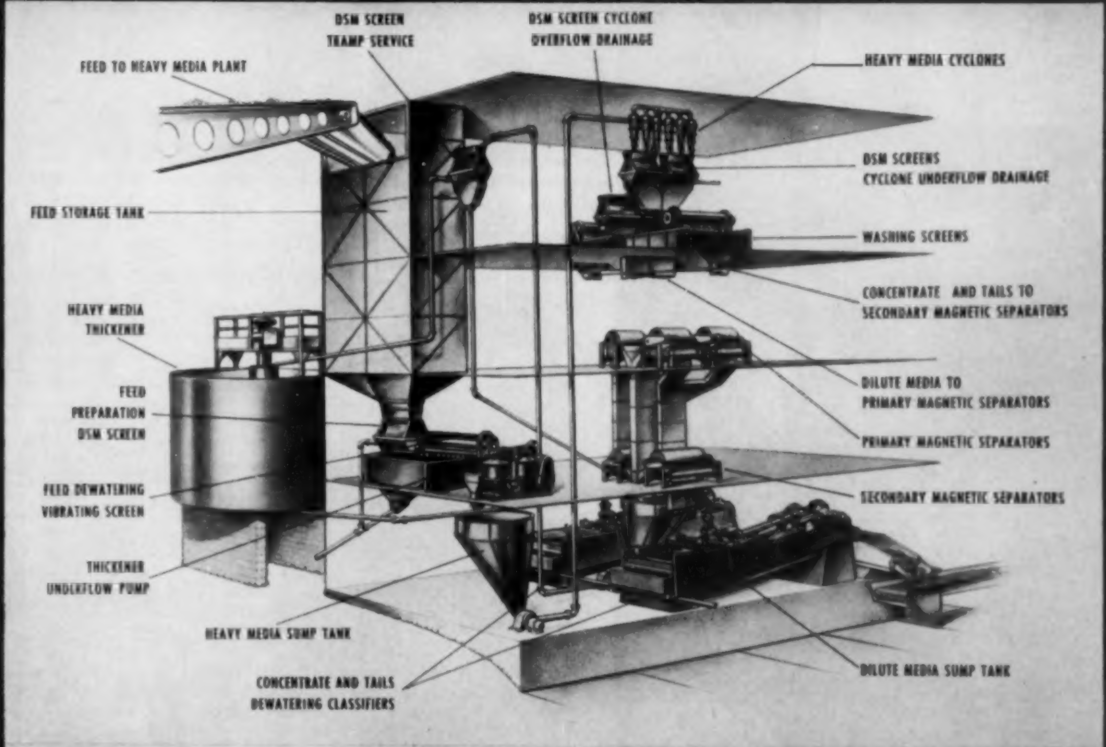
Colorado's Supreme Court has ruled that geiger counters or scintillators are valid in mineral discovery when, with other evidence, fair compliance with the discovery law is shown. Decision could affect other types of electronic prospecting in the event that new methods are devised. The single dissenting justice believed the ruling should have been reached through legislation, if at all.

Uranium Bonus Shipment!

A bonus, ten years old and never before claimed, was won by Lisbon Uranium Corp. when it delivered to the AEC the first 20-ton truckload of uranium ore averaging 20 pct U_3O_8. Arriving just under the deadline, the ore was shipped from the Big Indian district near Moab, Utah, on April 11—the day the bonus expired.

FOR IMPROVED CYCLONE HEAVY MEDIA PLANT OPERATION

THE Dorr-Oliver DSM Screen



TYPICAL CYCLONE HEAVY MEDIA PLANT

One of the most significant new tools for the mining industries is the Dorr-Oliver DSM Screen. The marked superiority of the unit for high capacity wet screening of materials in the 8-100 mesh range has been proven by exhaustive development and test work and in numerous fields of commercial application.

For the cyclone heavy media plant operator, application of the Dorr-Oliver DSM Screen results in improved overall plant operation –

First – Applied to feed preparation, the unit eliminates fines which contaminate media and lead to higher magnetite losses.

Second – For screening of magnetite from cyclone underflow concentrate and overflow fractions, the unit reduces the amount of media sent to the cleaning circuit to a minimum, consequently considerably reducing magnetite losses.

Third – On tramp service the Dorr-Oliver DSM Screen prevents foreign oversize material from entering the heavy media storage tank.

You'll want to know more about the DSM Screen. For complete information, write for a copy of Bulletin No. 2300. Dorr-Oliver Incorporated, Stamford, Conn.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U.S.A

On the roughest SEALTITE electrical

against oil, grease, water, dirt, chemicals, corrosive fumes, salt spray, weather.

SEALTITE is a flexible *and* liquid-tight electrical conduit. It gives maximum protection to your wiring when it must connect moving parts, absorb vibration, follow machine contours, flex into U-bends, be easily maintained or be safeguarded between misaligned outlets.

It is being used successfully in wet locations, in tunnels, power plants, steel mills, canneries, chemical industries and in many outdoor applications. Sealtite comes in three types:

TYPE U. A.— TYPE C.S.A. Specifications for Type U. A. (Underwriters' Laboratories Approved) and Type C. S. A. (Canadian Standards Association Approved). Construction: flexible galvanized steel core, positive ground and tough extruded outer cover.

TRADE SIZE (Ins.)	INSIDE DIAMETER Min.	INSIDE DIAMETER Max.	OUTSIDE DIAMETER Min.	OUTSIDE DIAMETER Max.	APPR. INSIDE BEND DIAM.	EST. WGT. (Lbs. Per 100 Feet)
3/8	.484	.504	.690	.710	6	30.0
1/2	.622	.642	.820	.840	7	36.6
3/4	.820	.840	1.030	1.050	10	48.2
1	1.041	1.066	1.290	1.315	12	87.7
1 1/4	1.380	1.410	1.630	1.660	15	116.5

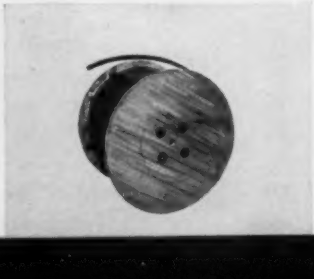
TYPE E. F.† (Extra Flexible)—for machine tools and industrial equipment. (Meets standards set by J.I.C.)

TRADE SIZE (Ins.)	INSIDE DIAMETER Min.	INSIDE DIAMETER Max.	OUTSIDE DIAMETER Min.	OUTSIDE DIAMETER Max.	APPR. INSIDE BEND DIAM.	EST. WGT. (Lbs. Per 100 Feet)
3/8	.485	.500	.695	.710	5	24
1/2	.620	.635	.825	.840	5	29
3/4	.815	.930	1.035	1.050	6	39
1	1.030	1.050	1.295	1.315	8	67
1 1/4	1.370	1.390	1.635	1.660	10	87
1 1/2	1.575	1.595	1.875	1.900	12	105
2	2.020	2.040	2.350	2.375	15	135
2 1/2	2.480	2.505	2.850	2.875	20	198
3	3.070	3.100	3.470	3.500	26	282
4	4.000	4.040	4.460	4.500	34	414

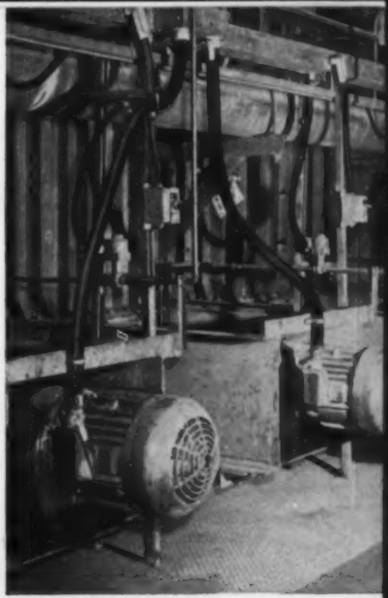
Commercial tolerances apply on above figures.

ELECTRICAL WHOLESALERS stock Sealtite. Buy it in long, random lengths on nonreturnable wooden reels, at no extra cost. Available in sturdy cartons that are easier to store and carry to the job. Liquid-tight connectors also are available from wholesalers' stocks. For information write: The American Brass Company, American Metal Hose Division, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

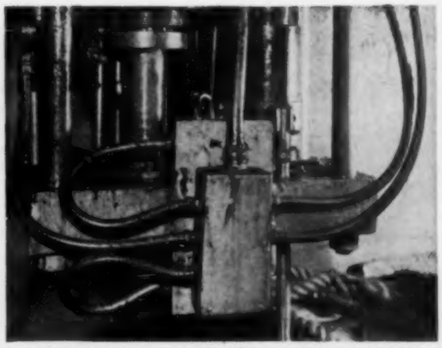
†Pat. applied for 58182



jobs in your plant conduit protects wiring



ABRASIVE GRIT around these sand pumps in a rod and ball mill pit can't faze Sealtite.



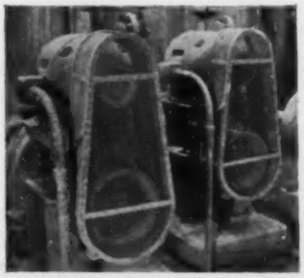
OIL, GREASE, WATER constantly cover these Sealtite control connections. Still no trouble.

BOILER HEAT and 6-inch expansion rise are easy service for Sealtite.

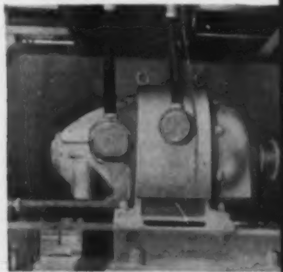
CHEMICALS. Sealtite shrugs off hot chlorine vapors in this plant—another example of its ability to resist chemicals and corrosive fumes.

WEATHER. Install Sealtite outdoors. It stands up under tropical sun and heat, rain, ice, and arctic cold. Protection is complete.

ON MOBILE EQUIPMENT Sealtite can take up movement, withstands weather, dust, vibration. It's fast and easy to install.



MOVEMENT AND VIBRATION that would crack rigid conduit are absorbed by Sealtite on connections for these tailings pumps.



ABRASIVE DIRT AND VIBRATION at this ball mill motor are tough enemies—but Sealtite can take it.

CUTAWAY SECTION of Type U.A. Sealtite shows tough polyvinyl jacket over flexible metal core. Copper conductor wound spirally inside conduit gives positive ground.

Insist on the conduit marked **SEALTITE**®

FLEXIBLE, LIQUID-TIGHT CONDUIT

an **ANACONDA**® *product*

U. S. Mineral Output, Consumption, Reserves—1957

Figures prepared by the Office of the Assistant Secretary of Mineral Resources, U. S. Department of the Interior, January 20, 1958.

Commodity	Unit	Mine Production*	Primary Consumption*	Mine Production as % of Primary Consumption	Commercial** Reserves	Years of Commercial Reserves at 1957 Rates: Mine Production	Years of Commercial Reserves at 1957 Rates: Primary Consumption
Antimony	ton	610	9,800	6	100,000	164	10
Arsenic	thousand tons	11	20	55	1,000	91	50
Asbestos, chrysotile	thousand tons	41	620	7	1,000	24	2
amosite	thousand tons	0	12	0	None	0	0
crocidolite	thousand tons	0	23	0	None	0	0
Bauxite	thousand LT, dry	1,500	7,700	19	45,000	30	6
Beryl	ton	460	4,600	10	10,000	22	2
Bismuth	thousand pounds	NA	1,700	—	30,000	—	18
Boron	thousand tons	960	700	137	Very large	Many	Many
Cadmium	thousand pounds	3,120	10,900	29	100,000	32	9
Chromite	thousand tons	160	1,750	9	500	3	—
Coal, anthracite	thousand tons	25,500	21,000	121	1,700,000	67	81
" bituminous & lignite	thousand tons	490,000	430,000	114	235,000,000	480	547
Cobalt	thousand pounds	3,200	9,600	33	100,000	31	10
Columbium-tantalum	ton	200	1,000	20	Negligible	—	—
Copper	thousand tons	1,075	1,350	80	31,000	29	23
Fluorspar	thousand tons	324	630	51	22,500	69	36
Gold	thousand troy oz	1,781	1,450	123	40,000	22	28
Graphite	ton	***	40,000	—	Small	—	—
Ilmenite	thousand tons	710	800	89	42,500	60	53
Iron ore	million gross tons	105	139	76	5,500	52	40
Kyanite	ton	0	7,000	0	Negligible	—	—
Lead	thousand tons	333.5	680	49	7,700	23	11
Magnesium	ton	81,300	47,000	173	Unlimited	Unlimited	Unlimited
Manganese	thousand tons	350	2,400	15	1,000	3	—
Mercury	thousand flasks	31.5	54	58	315	10	6
Mica, strategic	thousand pounds	180	10,000	2	Very small	—	—
Molybdenum	million pounds	61	38	161	2,200	36	58
Nickel	thousand tons	10	128	8	400	40	3
Nitrogen compounds	thousand tons	3,200	3,200	100	Unlimited	Unlimited	Unlimited
Phosphate rock	million LT	13.5	13.5	100	5,000	370	370
Platinum	thousand troy oz	21	721	3	150	7	—
Potash (K_2O)	million tons	2.2	2.1	105	250	114	119
Quartz crystals	pound	0.0	130,000	0	—	—	—
Rare earth metals	ton	1,500	3,500	43	2,000,000	1,333	571
Rutile	thousand tons	12	54	22	1,000	83	19
Salt	thousand tons	24,250	24,250	100	Unlimited	Unlimited	Unlimited
Selenium	thousand pounds	1,050	620	170	19,000	18	31
Silver	thousand troy oz	37,026	100,000	37	750,000	20	8
Sulfur	thousand LT	7,500	5,500	136	125,000	17	23
Talc, steatite, (block)	ton	0	150	0	Negligible	—	—
(grinding)	ton	10,000	10,000	100	1,000,000	100	100
Tin	thousand LT	0	57	0	Negligible	—	—
Tungsten	thousand pounds	7,577	8,605	88	140,000	18	16
Uranium	thousand tons	3,400	NA	NA	70,000	21	NA
Zinc	thousand tons	520	975	53	25,000	48	26

* Estimates—based on latest data available to U. S. Bureau of Mines.

** *Commercial* reserves as herein used mean known reserves of material that can be mined by present technology at prices not appreciably different from the average of the past few years, based on the latest data available to the U. S. Geological Survey. *Reserves* here include all classes (measured, indicated, and inferred.) They do not include extensive resources presently submarginal, or potential resources yet to be discovered.

*** Cannot be disclosed—but small.

How a little give adds a lot of life to... AMSCO CRUSHER PARTS

Concave ring and mantle of this *Hydrocone* crusher are made of the toughest steel known ... Amsco Manganese Steel. It *gives* a little, to take more punishment. *Hydrocone* is a registered trade-mark of the Allis-Chalmers Manufacturing Company.

Both mantle and concave ring crush a lot more feed because of certain properties of Amsco® Manganese Steel. The metal *gives* a little under crushing forces, absorbs stresses, resists cracking and chipping. Yet these same forces work-harden the surface of Amsco Manganese Steel to as much as 500 Brinell . . . a high hardness, stubborn to wear.

Amsco Manganese Steel Crusher Parts maintain their ductile undersurface and work-hardened surface even when worn thin. That's why Amsco parts endure severe abuse for so many work hours without letup.

To be sure of getting Amsco Manganese Steel, order replacement parts from your crusher manufacturer. Amsco makes manganese steel parts for most manufacturers of crushing, grinding and pulverizing equipment.

Amsco also produces other alloy steels with maximum wear resistance under particular service conditions

AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division • Chicago Heights, Ill.

OTHER PLANTS IN: DENVER, LOS ANGELES, NEW CASTLE, DEL., OAKLAND, CAL., ST. LOUIS; JOLIETTE, QUEBEC

Traylor -MADE
TY GYRATORY CRUSHER

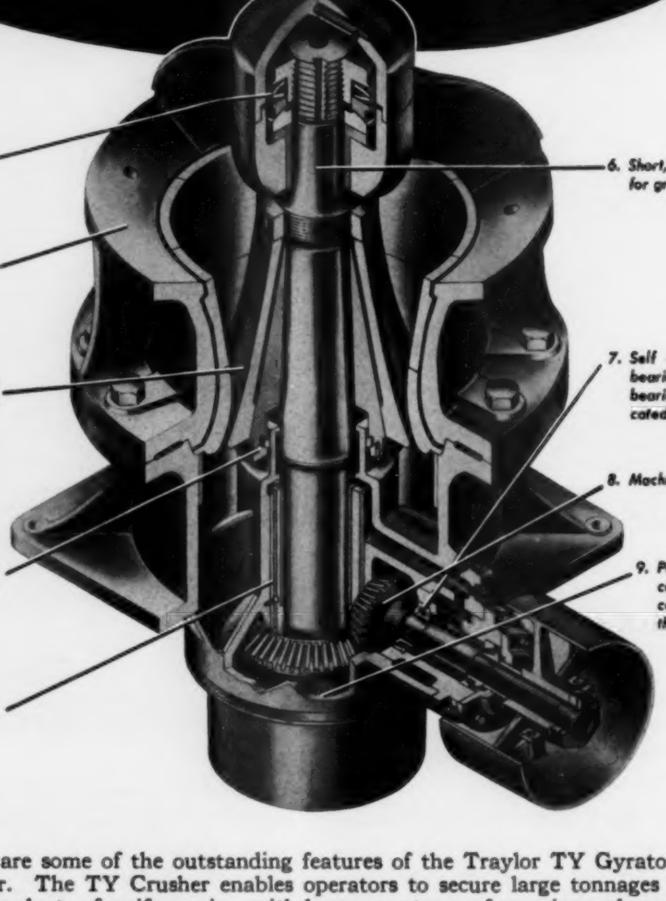
1. Spring suspension affords protection against tramp iron.

2. Cast steel frame with spider and upper shell cast integral.

3. Self-tightening Bell Head and Curved Concaves, of manganese steel.

4. Traylor dust seal excludes dust and grit from the lubrication chamber.

5. Bronze bushed eccentric assures longer life.



6. Short, extra heavy main shaft for greater strength.

7. Self - contained countershaft bearing, fitted with roller bearings, automatically lubricated.

8. Machine cut steel gearing.

9. Positive and automatic lubrication system, either self-contained or located outside the crusher.

Above are some of the outstanding features of the Traylor TY Gyratory Crusher. The TY Crusher enables operators to secure large tonnages of small product, of uniform size, with low percentages of oversize and waste fines. Write for bulletin No. 8112 today!

TRAYLOR ENGINEERING & MFG. CO., 1043 MILL ST., ALLENTOWN, PA.

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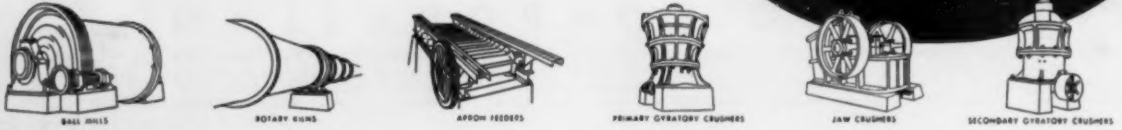


Scholarships

What kind of scholarship program does the nation need to provide a stronger working force of highly trained men in engineering or any other advanced study? Should we give large help to a small but very deserving number of students or should we give a little help to each man in a large group that, collectively, meets somewhat lower requirements? High quality or large quantity?

Senator Ralph E. Flanders sides with the former view. In testifying before the Committee on Labor & Public Welfare in mid-March, he heartily approved a statement by the Engineering Manpower Commission of the Engineers Joint Council that "The major problem is no longer one of student recruitment, but of educational *quality* all along the line and the provision of adequate facilities and faculties for higher education in engineering and science." In a campaign against a bill which would provide for 40,000 new scholarships every year for six years, he cites the opinions of a number of educators in the science and engineering fields:

Dr. Maynard Boring, chairman, Advisory Board on Education, National Academy of Sciences—"U. S. schools need overhauling, all the way back to the first grade . . . Schools should stress quality, not quantity, in awarding scholarships."

Dean Martin Mason, George Washington University Engineering School—The U. S. public education system is "obsolete and incredibly poor." If the Federal Government goes through with plans to provide $2 billion for science scholarships, at least half will be "a pure waste of money. . . . It will put the Government in the position of handing to people who already have made a mess of things more money with which to do more wrong. . . . Our schools are not fulfilling what should be their main function —basic education and the stimulation of minds. Pupils spend half their time learning social graces, automobile driving, and in building their bodies."

Dean George R. Harrison, MIT School of Science —"Students coming to MIT can't read, write, or spell, and some don't know the alphabet."

Senator Flanders, with three co-sponsors, proposes a piece of legislation which, he says, has a very simple purpose: "It is to put so high a premium on real scholarship that the demand for it will arise spontaneously from parents and students. It likewise seeks to establish competition in scholarship between the secondary schools of a state, and between the states themselves."

The bill would provide 1000 scholarship recipients with a maximum of $2500 a year for four years. "This is sufficient to give the student who is without means himself, or whose parents are without means, assurance of an education on equal terms with anyone else in the country, rich or poor." The awards would be called National Scholarships and would include a certificate signed by the Secretary of Health, Education, and Welfare. In addition, no matter what his circumstances, says the senator, the student will receive at least $500 and this "gives a Nobel Prize aspect to the plan."

The bill further proposed that $3 million be authorized for the first year, $6 million for the second, $9 million for the third, $12 million for the fourth and so on down. There is therefore a surplus of funds beyond the maximum of 1000 $2500 scholarships. Add the amount left over when the scholar is allowed less than the maximum and a considerable surplus will be available. This surplus would be allocated by the program's 13 board members (presidentially appointed) for state scholarship programs, and paid to the states in the same ratio as the National Scholarships were awarded among the states in such fiscal year.

Each state would prescribe and administer its own program and so, Senator Flanders believes, give them "a lively interest in raising the scholarship standards of their educational system." The provision, likewise, "gives parents and pupils a lively interest in seeing to it that those standards are raised. There is here no per capita distribution. It is a distribution on the basis of achieved and measured scholarship and not quantity, and . . . the provision of only 1000 scholarships, plus the number supported by the state scholarship programs, will put no unendurable burden on our institutes of higher learning."

Corporate Struggle—Find a New Name

Your company's name is Galvanized Dish Pans Inc. A terrific name. Anyone looking at your letterhead would know that you make galvanized dish pans and that is that—short and simple.

The trouble is that about twenty years ago you started making a few changes in your company make-up. You decided that, with your well-based knowledge in the field of dish pans, it would be an easy step to branch out into the manufacture of cooking utensils. It worked out so well that you formed a utensil subsidiary, and about five years after that you made another step—going a little further afield—into the steel furniture business. Opportunities for still more diversified business came along and you took them. Today you even have the Atomic Reactor Shielding Div. of Galvanized Dish Pans Inc. Most people are surprised at the link, others don't even realize there is one, and some think the father belongs to the child. The old name has been outgrown and you must start thinking about a new one.

A little farfetched? Sure, but a similar situation was pondered recently by the 24-year-old National Cylinder Gas Co. which has spread widely from its initial interest in bottled gas. Before its new-name researchers reached a solution, they learned just how hard it is to find a company name that is 1) short and simple—easy to remember, 2) easy to pronounce—in just one way, and 3) representative of your business but not infringing upon established names.

The company found that many words such as Universal, Superior, Acme, Precision, Continental, and Federal were already much in use. In addition, in Thomas' Register of American Manufacturers there are 934 concerns using the name American, 610 Uniteds, 533 Nationals, 397 News, 314 Generals, and 328 Standards.

Many of the names first suggested had to be discarded and even in a second roundup the mortality rate was high. The surviving names were scanned by a consulting firm which eliminated those that had unpleasant foreign-language meanings or might be mispronounced. It was an obligation to avoid the experience of one concern that was all set to introduce a new drug when at the last minute it discovered that there was more than one way to pronounce *Damital*.

After much searching (an electronic computer put to use turned out some 37,000 combinations—some shockers and many unpronounceables) the field was narrowed down to three that were both suitable and available. More testing brought forth the winner—Chemetron—a word composed of elements taken from the company's various industrial interests: chemicals, metals, and electronics.

The final hurdle, stockholder approval, is coming up on May 6. National Cylinder Gas will convert to a company division and the new name, Chemetron Corp., will be submitted by relieved directors.

How Is Joe Doing It?

On page 560 of this issue one of our authors holds forth on a problem which, although it affects others, plagues the mining field in particular. The problem is that of communicating ideas within the company framework.

Mining operations are generally widespread and difficult to oversee. As author F. N. Parks points out: "The advantages of *sight control* of operations are lost to the men in top management, who cannot readily observe the condition of the plant, the morale of labor, the effectiveness and working relationships of middle management."

Even local mine managers are often forced to be executive hermits who operate without close supervision, get few ideas from their colleagues, and primarily depend on operating reports to keep themselves and their superiors informed. Efficiency, without a doubt, is helped if there is a meeting of minds—often.

We started all this to point an approving finger at a group that is doing something about the situation. Kennecott Copper Corp. recently held a technical meeting of representatives of the company's various domestic properties to discuss milling practices—to permit a general sounding of ideas and to provide for exchanges that could lead to the solution of common problems. The first session took place at the Chino Mines Div. in New Mexico. Committees on mining and smelting have been similarly formed by Kennecott, with first meetings held recently at Hayden, Ariz., and Salt Lake City.

Copper Outlook

Before his untimely death on March 31, Roy H. Glover, chairman of the board of the Anaconda Co., gave the industry his views on the outlook for copper in a Denver speech delivered at the recent 53rd Convention of the International Union of Mine, Mill & Smelter Workers.

For a number of reasons, Mr. Glover stressed, the copper industry will arise from its depressed state and, moreover, its long range outlook is excellent. For the short term, he pointed to inventory liquidation as a strong factor, commenting that "this liquidation has been carried to the place that immediate delivery is now demanded of our fabricators on nearly all orders and, while numbers of orders have increased many fold over those received in days when our business was good, the quantities of each order are very much less. Actually, in some instances we have had to increase the number of order clerks to handle a much lower volume of business. Many of our very important customers now freely say that their inventories are on the tail gates of our trucks.

"In the second place, if you add the amount of already announced reductions in 1958 world production of around 275,000 tons to the before mentioned 188,053 tons of 1957 decrease in deliveries to U. S. fabricators, which was largely accomplished through inventory liquidation, you arrive at a figure of 463,053 tons against year end world stocks of 458,340 tons.

"Statistically, therefore, contrary to general impressions, our industry is not in a bad situation. Inventories of users have been liquidated to the place where any substantial reversal in the general trend of business should cause such a demand for our products as to result in prices sufficient to again support higher cost properties that have been curtailed or closed, and the resumption of normal operations in our fabricating plants. When this reversal in general business trend will occur is therefore the only question."

Mr. Glover pegged the long range outlook to growing world population and industrialization. As one example he cited "the tremendous increase in the European use of copper during the 1955 to 1957 period of 21.4 pct." And he stressed that "the 1957 increase alone was 208,382 tons. This increased European demand could not have been met from current production except for the fact of the decline in the deliveries to U. S. fabricators—between 1956 and 1957—of 188,053 tons.

"In only two of the past ten years have deliveries to fabricators in the U. S. been as low as in 1957 and these were the years 1949 and 1954 which were followed each time by two abnormally high delivery years. This reduction in the U. S. has been accomplished, as it was in the other two years, by resort to inventories; but this time the available copper has gone to Europe to help fulfill the ever-increasing standard of living that is developing there. As a matter of fact, this European demand is becoming so insistent, that shortly after the first of the year we had placed all of our copper from our planned production for the year 1958, plus our 1957 carryover, for delivery during 1958. Since then, the principal function of our sales organization has been to explain to our European customers and others who wish to become customers, why it is not possible for us to deliver to them additional 1958 copper.

"The answer is of course simple. The present price does not justify the production of available higher cost copper."

Mr. Glover's address was an unusual one, not because of his comments but because he spoke before a union which has often skirmished with producers. He was invited cordially, and he accepted graciously.

We are reminded of a similar conclave. At the most recent Coal Show of the American Mining Congress, one of the featured speakers was a venerable gentleman named John L. Lewis.

Q: WHICH D7 IS THE OLD-TIMER?

This Cat D7 Tractor with No. 7S Bulldozer feeds the grizzly about 450 tons of gold ore a day.

This Cat D7 Tractor with No. 7S Bulldozer, working in heavy wet sand, is building a 2-mile-long dike.

A: If you know your Cat Diesel Tractors, you've spotted it on the left. It's 12 years old. With the new D7 and a D8, it's used by the London Extension Mining Co. in an open pit mining operation 30 miles from Beowave, Nevada. The climate's rugged. Temperatures range from −20° to 110°.

Q: What does the company think of the machines?

A: It has had Caterpillar-built equipment since 1936. General Superintendent R. B. Warmbrodt says: "We find the tractors are rugged and stand up well."

Q: How are the machines used?

A: Generally one is kept in the pit cleaning up around shovels, while the other feeds the grizzly 450 tons of ore a day. The machines also strip overburden, handle tailings and knock down dump piles from trucks at the stockpile. Two months a year, the new D7 builds about 2 miles of dike to control tailings. The machines are on duty 7 days a week all year 'round.

Q: How do the D7s compare in production?

A: Good as the old D7 is, it's not in the same league with the modern, heavy-duty D7. Of course, that's to be expected. Caterpillar constantly builds improvements into its machines. The new D7 is more powerful, easier to operate and more rugged. For example, among many modern features, it has the oil clutch that delivers 1,500 hours without adjustment.

Q: Has the company any other Caterpillar equipment?

A: Yes. Two engines in shovels and two in compressors. Mr. Warmbrodt says: "Since we're far from supply, we find the parts interchangeability of Caterpillar units a decided advantage. We also get excellent service from our Caterpillar Dealer!"

Add all this up and you get some of many reasons why it will pay you to use a Cat Diesel Tractor on your operation. You can't beat the combination of rugged machines, parts availability and good dealer service. Ask your Caterpillar Dealer to give you the low-down on the new D7's high productive capacity. Better still, watch one work —ask him to demonstrate on your job!

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

CATERPILLAR

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

FOR DEPENDABLE PRODUCTION USE RUGGED CAT DIESEL TRACTORS

MINING engineering

DRIFT

Statesmanship and Salesmanship in Mining

IN a period of economic stress the mining industry is showing encouraging signs of its underlying strength and vitality. The problems are not single—the answers are not simple—nor will solutions come quickly, but the industry is facing its problems with statesmanship.

Classically, mining is one of the first spots in the economy to feel adverse economic pressure. Like a seismograph it registers underlying stresses—and early. Producer and consumer inventories are a two-edged sword. When storm signals fly, the manufacturer or consumer starts living on his fat (or inventory). When an upturn begins, remaining inventory is a cushion delaying the impact of fabrication upon primary production of metals.

Speaking particularly of copper, lead, and zinc, there is another and chronic problem. To draw a parallel, automobile makers can compete furiously with one another, but Chevrolet management (for example) does not have to speculate about the possibility that three million Austins or Fiats will be imported next year. At least they don't, yet. Readers are free to complete the parallel in their own words.

A newer problem arises from competition, not only between metals, but from nonmetals as well. Turning to the auto makers again, it is doubtful if Ford management is losing any sleep over the possible replacement of the station wagon by the horse and buggy, the helicopter, or the guided missile. One example will suffice for the opposite situation: you can make pipe or tube out of iron, copper, lead, aluminum or . . . plastics.

Attack on these manifold problems is spontaneously developing along three lines: better information, longer-range planning, and greater attention to product development.

Better information on metal stocks will help, since metals consumers almost invariably accentuate the industry cycles. Without full and prompt information on stocks and metal consumption, neither producer nor consumer can act wisely.

Longer-range planning is probably reflected in the response of the coppper industry to the past year of downturn. Neither was production kept full blast, nor was it cut completely. The strain on the cash position of many companies has been severe, but nonetheless management has fought to maintain economic production rates while retaining realistic confidence in the future.

Product development and research on both company and industry level pays multiple dividends. In the first instance it is vital defensive action for producers of metals which would otherwise lose ground to newer and more aggressively merchandised metals. Second, it is important if metals are to retain their position in the face of new and wholly different materials: plastics, glass, other ceramics. Third, in bringing new products to the ultimate consumer, research and development help build "identification" for the mineral industry with a public to whom mining is a remote thing. A pot in the kitchen is a part of your life, industry in the abstract is not.

Finally, we think it reflects considerable credit on the high percentage of engineer-executives in the top ranks of the metal companies that company has taken the broad approach to industry problems. Rather than crying for hand-outs or tackling only production problems, mining is fighting back intelligently. A newly growing salesmanship is being backed by something else. We call it industrial statesmanship.—*R. A. Beals*

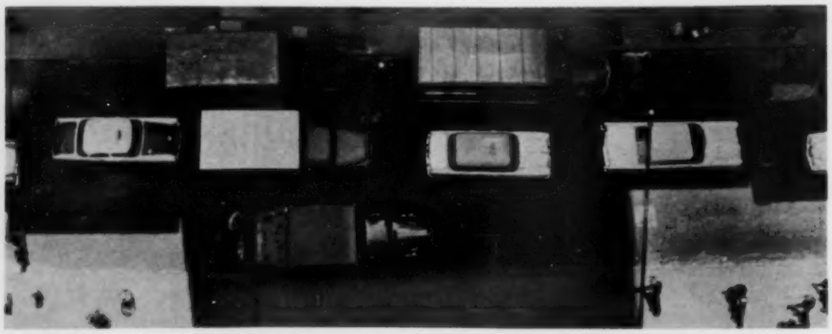
PHOTO REPORT

NEW BUILDING PROGRESS

As reported in *Drift* last month demolition of old buildings on the 47th St. site has been completed, and detailed plans and studies for the new structure are well underway. As this issue was being sent to press the $5 million industry-business phase of the fund campaign had passed the half-way mark toward its goal. Target date for the building program is 1960.

TODAY

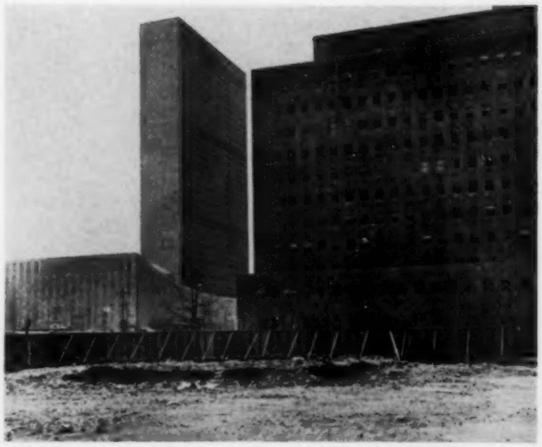
Crowding, congestion, and related problems are evident in these candid views of the soon to be replaced 39th Street location of the Engineering Societies Building. Aside from structural problems, these were among factors in decision against rebuilding at the present location.



Traffic congestion on 39th St.—Looking down from the present building.

and TOMORROW

Site of future United Engineering Center offers long range values and protection.



Looking across cleared site for new United Engineering Center. Target date is occupancy by late 1960.

The panorama southeast from the new building site, and looking toward the East River and UN buildings.

Management Organization Principles Applied to the Mining Industry

by F. Newton Parks

Despite mining's unique problems—largely geographic and physical—fundamentals of management organization are as valid for mining companies as they are elsewhere throughout industry.

SOUND management organization is as essential to a mining operation as sound mining practices, exploration methods, concentration processes, or marketing methods. In fact, if a mining company is well organized, with the right people in the right management positions, it can be reasonably assured of the adequacy of its operating practices.

Management problems in mining are unique, but certain principles of organization are universal. These principles should be used as ground rules in mining as they are in other industries.

Organization Requirements Peculiar to Mining — Industry Cycles

In the first place, the mining industry is highly cyclical. Commodities are normally more volatile in their economic swings than are manufactured goods, and in mining these swings are even more pronounced in terms of metal prices, production output, and company profits. All this, of course, has significant organization implications. A mining company in particular cannot afford the luxury of over-organizing. Organization must be reasonably lean in terms of personnel and staff functions in order to maintain proper overhead costs during periods of depressed metal markets.

Still, owing in part to the necessity of running a tight organization, mining has been reluctant to adopt certain staff services that other industries have found worthwhile. Industrial engineering, production control, management development, market research, public relations, and product development are all less fully elaborated in mining than in other industries. The planning, research, and control services these staff functions perform may well provide the competitive edge for the long term that more than offsets their short-term costs. But it requires good judgment to determine the amount of staff organization that is justified. The industry now finds itself, therefore, in this position—there are organization elements it cannot afford, yet these are the very elements it cannot afford to be without.

The cyclical nature of the industry is also reflected in the personnel policies and practices of mining companies. There is less emphasis on developing future management than is normal in business, and management turnover is an accepted fact as organizations expand and contract like an accordion with mining prosperity and depression. In general, the lower and middle levels of management are not preserved as carefully as in other industries. As a result, only the more persistent, and not necessarily the ablest, of management personnel stay on and battle their way to the top.

F. NEWTON PARKS is a Partner in Booz, Allen & Hamilton, Management Consultants, Cleveland, Ohio.

— and Dispersion

Another industry characteristic affecting organization is the dispersion of operating locations. Most mining properties are remotely located, away from corporate offices. They may also be widely scattered—in different states, countries, or continents. The advantages of *sight control* of operations are lost to the men in top management, who cannot readily observe the condition of the plant, the morale of labor, the effectiveness and working relationships of middle management. Consequently an unusual degree of authority and responsibility must be placed in the hands of local mine management.

Not only does the distance factor place a premium on the competence of local managers to operate without close supervision, but they themselves have less opportunity to exchange ideas and practices with other executives in the company. Moreover, widespread and remotely located operating properties call for an unusually sound system of reporting operating results to headquarters, if general management is to be kept properly informed.

At the mine itself there is a parallel problem. Inaccessibility of workings limits the sight control of on-the-job management. A factory manager can take an hour or so to walk through his plant and get a fair idea of what is going on. For the mine manager, a tour of operations makes strenuous demands.

Generally speaking, then, the mine manager has the same relative problem as his own boss back at the corporate office—he must rely heavily on his supervisors who are at the working faces and he must make certain that his own system of management reporting keeps him fully informed.

Shortage of management personnel is another organization problem that is particularly evident in mining. Perhaps in no other industry is there a similar lack of management men in their middle thirties to middle forties. The current shortage of mining graduates from the mining colleges threat-

ens to extend this situation, in spite of the growth in raw material requirements.

In mining, then, there are problems of communication and management control not necessarily found in industries where top executives have more personal contact with operations. Nevertheless, mining companies can still take an orderly approach to their organization problems, in much the same manner adopted in other industrial fields.

Need for Stated Company Objectives

The first organization requirement, in mining or elsewhere, is a clear statement of purpose, for it is the pattern of objectives that determines organization structure, types of personnel, training requirements, and salary structure.

In other words, what is the company organizing for? This requirement may seem so apparent that it hardly needs discussion. Yet it is not unusual for directors and top management to fail to make clear just what their basic objectives are—beyond the obvious desire to improve earnings. Even more often, top management fails to pass down its operating objectives to middle management out at the mine or mill. One way to insure that operating objectives are transmitted is to require that they be put in writing.

Here are further questions that must be answered: Is the company to confine its interests to nonferrous metals? Is the product to be sold as a concentrate or a refined metal—perhaps even a fabricated shape? Is expansion to come from earnings or borrowings? Does the company want to control its own marketing?

To oversimplify, assume that a mining company decides to diversify by going into uranium. To accomplish this objective its organizational requirement may be a completely autonomous uranium operation. On this basis, organization can be developed that satisfies the particular operating requirements of the venture. Perhaps this autonomous organization has a need for an exploration unit, a marketing unit, a production unit, and a financial control unit. To what degree, then, must plans and management controls be integrated with the mining parent? Where is the management personnel to come from, etc.?

At the operating level, objectives should be spelled out in terms of costs, volume, preventive maintenance, community relations, or any other area vital to the effectiveness of the operation.

Need for Organization Structure

At the outset, executive responsibility and authority should be clearly defined—and this information should be well understood by all concerned. It is surprising how often this basic need is recognized without being followed through.

One way to assure follow-through is to set forth executive duties in an organization manual. In many corporations it is standard practice to use organization charts and position descriptions, which point up overlapping duties and clarify what is expected of each man.

But in mining companies this practice is still rare. Some believe that organization charts, written policies, and position descriptions prevent flexibility and restrict authority and initiative. If so, it is only because their purpose is misunderstood. Position descriptions merely outline a job; neither charts nor descriptions can define all the channels of executive communication—or substitute for common sense in the conduct of business.

Strangely enough, the practice of stating policy and defining positions is often discredited by top management, whose job it is to organize the enterprise. Frequently these same top management men fail to realize that the delegation and spread of responsibility which they themselves understand may not be understood by the operating management.

Need for Organization Balance

In designating jobs, it is important not only to assign related duties, but also to insure reasonable work loads. When a management staff combines heavily loaded and lightly loaded executives, friction inevitably develops.

To some extent a manager can control his own workload by delegating responsibility to subordinates, but there is considerable disagreement as to how many subordinates a manager should have. Some organization authorities say five. Some say seven or more. Actually, there is no categorical answer to the question, since it depends on the scope of the manager's job, the degree of coordination required, and the competence of subordinates. Some subordinates may add to an executive's work load, and others, such as executive assistants, may lessen it.

Generally speaking, it is advisable to have as few assistants as possible throughout the organization. For one thing, subordinate department heads should not have to work through an assistant to get to their superior. Furthermore, if work assignments of all managers are set up soundly, an assistant becomes an expensive *fifth wheel*. This is not to say that assistants to superintendents, managers, vice presidents, or presidents are never justified. When an organization is constructed to encourage the practice, however, it becomes a heavy expense as well as a cumbersome organization device.

The assistant position is often set up as a training ground. This is not generally good practice, as the job usually does not carry responsibility for results—a training fundamental. For the most part, future executives can be more effectively trained in *line* positions, in which they bear responsibility to get operating results. Although special study assignments point up a man's analytical powers, they do not show up his management capacity. The job of a manager is essentially to plan, to organize, to coordinate, to control results, and to motivate people. He learns these things by managing.

Organization Reporting Relationships

A man should have only one boss, and he should know who this is—a seemingly obvious organization principle that is often violated. He should also have some understanding of his boss's job and the reporting relationships of others throughout the organization. With these factors clear, he can go about his own job with confidence that those who must be kept informed are being informed. Furthermore, he will understand the limitations on the authority of others. Of course, the need for this understanding increases with the size and complexity of the company.

Planning the Organization

Organization planning is the practice of anticipating and providing for organization requirements before they develop.

For example, when a new mining property is being contemplated, the requirements for top, middle,

and first level organization should be planned early in the project—at the same time, or before, the technical decisions are made as to mining methods, shaft location, townsite, and other fundamental factors. The sooner the organization is developed and staffed, the sooner the organization can contribute to the early management thinking.

What will the organization structure be? What are the working relationships with other parts of the enterprise? What will be the scope of each job? What will the salary structure be? How much management manpower will be required, and where will it come from—must it be trained, transferred, or brought in from outside? What qualifications are required for men in the various jobs?

The need for company planning is not confined to new properties. Every company should have definite plans as to who the next president or operating vice president will be, the extent to which candidates are adequate or unqualified, and what will help to make them adequate. Good organization planning will take this thinking on down the line in engineering, sales, finance, and all other functions of the business to the extent that first level supervision, as well as top and middle management, is being developed.

A few years ago a number of major U. S. producers went outside their companies to replace their retiring chief executive officers. One major company has gone outside twice in the past two years for its president. These moves would not have been necessary if sound organization planning had been accomplished in the first place.

Choosing and Developing Executives

Well defined organization concepts and practices are of little value without the management team to make them click. Selecting and developing the various team members and then getting them to pull together to accomplish the overall job is part of the organization problem a company faces.

The problem of staffing an organization after the desired structure is set up and the jobs are defined cannot be solved theoretically. The practical approach is to match the desired organization with available manpower to arrive at a reasonable solution. Although organization should not be built around people, the strengths and weaknesses of existing personnel cannot be ignored.

In some instances the available manpower may not be able to produce the desired result. Management must then either staff certain positions with less than adequate personnel and accelerate their development or go outside the company for more executives. For the most part, it is unquestionably advisable for management to develop its people from within. On the other hand, it is occasionally desirable to bring to the company a fresh point of view from the outside. Moreover, expansion or diversification may leave a company no alternative than to hire additional management.

Selection and development of executive personnel can be carried out on an organized basis with favorable results. Organized selection practices are common in major oil, chemical, and manufacturing companies. The mining industry can expect the same return.

Compensation of Executives

Organization and compensation are inseparable. Obviously, responsibility should be closely related to a manager's income. Similarly, each executive should be paid on the proper scale relative to that of his associates both in the industry and in the company. Unfortunately, company salary structures often grow haphazardly, with resulting inequities, when they should be logically developed and based on evaluation of the relative worth of positions to the company.

Extra compensation can be an effective incentive for management, or it can deteriorate into a year-end *handout*. It will be an incentive to the extent that it ties into management appraisal, budgetary control, and cost control. It will be a handout to the extent it becomes a routine, non-discretionary bonus.

Summary

A mining company, like any other enterprise, can benefit from a careful approach to the problems of organizing its management. Seldom will an effective management organization just happen. Like any other management device, organization must be built on basically sound practices, planned, developed, and controlled.

A number of principles pointed up throughout this discussion can be used as organization yardsticks:

1) Spell out the objectives of the enterprise and put them before the management and stockholders. These objectives may not be as obvious or as easily written down as they first appear to be.

2) Define the organization structure and management positions. If they are not readily definable, management troubles probably exist.

3) Give the same emphasis to planning organization as to planning ore reserves. There is such a thing as *manpower depletion*.

4) Relate the compensation structure to organization structure. Salary ranges should parallel the scope of duties and responsibilities. Use bonus plans to get extra performance.

5) Recognizing the cyclical nature of the mining industry, plan for organization balance. Do not over-organize, but recognize that the planning, analysis, and control provided by sound staff functions may offer solutions that are the answer to long-term competitive pressures.

6) Avoid arbitrary departmental cutbacks in times of depressed metal markets. This practice cuts out muscle as well as fat. Cutbacks must be engineered by careful analysis.

7) Develop the company's future management long before positions must actually be filled. Develop the men on the job in *line* positions, not as special assistants. Training programs, suggested reading, and college *retread* courses only supplement the more important on-the-job development efforts.

8) Delegate responsibility to the men at the operating properties who are close to the problems—once the jobs are staffed by able men.

9) Then, oversee operations by means of control reports that are timely and to the point.

10) Balance the executive work load and assignments. An executive with a light load may appear competent, whereas the heavily loaded man may seem inefficient.

11) Be sure that everyone knows who his superior is, and *vice versa*. Relate responsibility and authority.

These eleven principles are valid in almost any type of enterprise. Unfortunately, they are sometimes compromised for the sake of expediency. Compromise should be the exception, not the rule.

The Moa Bay—Port Nickel Project

by Forbes Wilson

IN February 1952 Freeport Sulphur Company started exploration work on a group of lateritic deposits at Moa Bay, Cuba. As a result of successful exploration work and a vast amount of metallurgical research over the past five years, these deposits will soon become a new Free World source of nickel and cobalt.

Moa Bay lies on the north coast of Oriente Province, the easternmost part of the island, about 600 miles east of Havana and about 40 miles east of the U. S. Government nickel plant at Nicaro.

Sufficient ore reserves have been developed in this area to support a large commercial operation with an assured life of 20 to 25 years. The measured reserves of lateritic nickel ore in the sections explored to date amount to more than 50 million tons averaging 1.36 pct Ni, 0.13 pct Co, and 46 pct Fe.

Processing of the Moa Bay ores will involve acid leaching to extract nickel and cobalt from the iron laterites, followed by precipitation of metallic values as a sulfide concentrate and the ultimate extraction of nickel and cobalt metals by selective hydrogen reduction of sulfate solutions. This process has been fully tested in two pilot plants over a period of about two years.

Construction at Moa Bay was started several months ago and ground was recently broken at Port Nickel, Louisiana—near New Orleans—where the refining facilities will be located. The entire project will be conducted by the Freeport subsidiary, Cuban American Nickel Co.

F. WILSON is Vice President, Freeport Sulphur Co., New York, N. Y.

Characteristics of Lateritic Deposits

Over the past 20 years Freeport Sulphur has made detailed studies of many small laterites found on the U. S. west coast as well as the major lateritic areas in eight foreign countries. In all cases nickel-bearing laterites have been formed by the weathering of basic igneous rocks under tropical climatic conditions. Serpentinized peridotite—one of several ferro-magnesian rocks favorable for the development of nickel-bearing lateritic deposits—contains about 8 pct Fe, 40 pct SiO_2, and 37 pct MgO. The nickel and cobalt content of the original rock is on the order of 0.22 pct, with a nickel-cobalt ratio of approximately ten to one. These two elements are believed to exist in silicate form within the crystal lattice of the mineral olivine.

In the weathering of the basic rock substantially all of the silica and magnesia is removed by solution, resulting in a residual concentration of iron, nickel and cobalt. The ore column of a typical iron laterite, such as that found at Moa Bay, contains 46 pct Fe, 1.36 pct Ni, 0.13 pct Co, 2.5 pct SiO_2, and 0.7 pct MgO. Comparing these analyses with those of the original rock, it can be seen that the ratio of iron concentration is approximately 6 to 1. The ratio is slightly higher for nickel due to a downward migration of this element which leaves a capping of high iron material, low in nickel content, to be removed as overburden in the mining operation.

Underlying the iron laterite and immediately on top of the unaltered basic rock there is usually a thin layer of material which we refer to as serpentine ore, containing about 22 pct Fe, 1.5 pct Ni or

more, and 20 pct MgO. In the Nicaro deposits, owned by another Freeport subsidiary, and now supplying the ore needs of the U. S. Government-owned plant, the underlying serpentine-type ore constitutes about 40 pct of the total lateritic ore mined. At Moa Bay, however, underlying serpentine ore is lacking in many sections of the deposits. The average ratio for all orebodies is about six to eight parts of iron ore to one part of serpentine ore. It was this feature combined with a relatively high cobalt content, that made the acid leach process practical for the Moa Bay iron-type ores. At Nicaro, by contrast, the mixture of iron and serpentine-type ores would make acid requirements excessive. The small amount of serpentine ore underlying the iron ore at Moa Bay, which would similarly require large amounts of acid for nickel extraction, will be stockpiled for future treatment by another process.

Review of Mining Plans

The orebodies at Moa Bay were developed by about 60,000 ft of auger drill holes on 330-ft centers. For mining control additional holes will be drilled to serpentine on 110-ft centers and to top of ore on 55-ft centers. Intermediate drill holes are needed to find the overburden—ore cut-off and to determine the bottom ore limit.

The top cut-off at the present time is 1 pct nickel. This is established for stripping control by plugging the drill hole with ore to the cut-off and inserting a paper container filled with slaked lime. Scrapers used to remove overburden will smear the white lime on the brown ore, giving the operator a visual control.

The bottom ore cut-off is in the range of 30 to 35 pct iron, which coincides with a sharp increase in magnesia content and usually a distinct color change from light brown to light yellow.

While the deposits vary from 10 to 100 ft thick, the average thickness of the ore column in all orebodies is 22 ft, with an overburden-to-ore ratio of about 0.5 cu m per ton of ore. All laterites are soft and earthy or clay-like in character. Furthermore, they have a high moisture content, which at Moa Bay amounts to 36 pct. These features cause difficulties in loading and handling, and were considered in the selection of mining equipment.

The overburden will be removed by conventional scrapers, and in some areas, where it is more than 15 ft thick, small draglines will make the initial cut. Mining will be done by draglines, operating on top of ore, and ranging in size from 2½ to 5-cu yd capacity. Both crawler-mounted and walking draglines will be used, with larger units operating in areas where digging depths range up to 80 ft or more. The draglines will load 30-cu yd diesel haulers, which will transport the ore to a slurrying plant at the center of the mining area. The serpentine or high-magnesia ore underlying the high-iron laterite will be mined at the same time as the ore mined for processing, but, as mentioned, it will be stockpiled for future treatment.

The process plant is designed to treat just over 2 million dry tons of ore yearly. The mine, operating on a two-shift basis 5½ days a week, will therefore have a production demand of 8450 tpd of dry ore. Because of the high moisture content of the ore and the need for removing a large amount of overburden, about 20,000 tons of material will be handled each operating day.

Ore Conditioning and Transportation

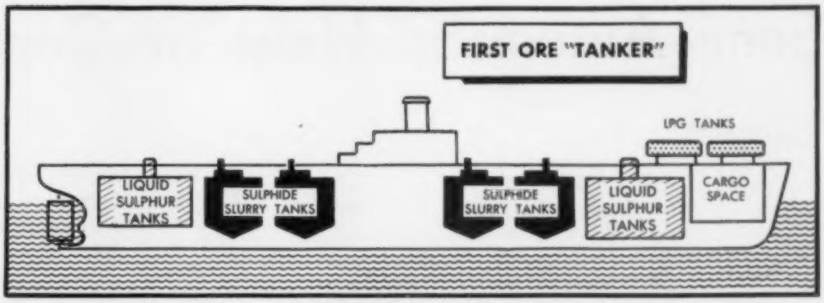
An unusual feature of lateritic nickel deposits, particularly their iron component, is the extremely fine natural particle size of the material. The ore as mined at Moa Bay will be about 90 pct −325 mesh. As previously mentioned, natural processes have been responsible for considerable concentration of metal values. These same processes have eliminated another normal milling function—that of crushing and grinding. Even the high moisture content of the ore is helpful in preparing slurry.

While some concentration of cobalt values has been found in the coarser fractions from 20 to 65 mesh, it has been determined that material coarser than 20 mesh contains only minor amounts of nickel and cobalt. Therefore the screening and slurrying plant has been designed to remove and discard all material coarser than 20 mesh and to prepare a slurry of about 35 pct solids for hydraulic transportation to the processing plant.

Incoming ore will be passed over a 20-in. grizzly to remove the small amount of rocks expected from pinnacles of undecomposed material extending up into the iron ore. A pan feeder under the coarse grizzly will deliver ore to a shaking grizzly, which will remove another small amount of −20 in. +5 in. material, mostly in the form of undecomposed er-

At Moa Bay, Cuba, wharves under construction in ship channel and turning basin will be shipping point for nickel-cobalt ore concentrates.

At Port Nickel, La., on the Mississippi River below New Orleans, earthwork is in progress for a refinery that will process 50 million lb of nickel and 4.4 million lb of cobalt yearly.



Nickel-cobalt tanker will carry slurried concentrates from Moa Bay to Port Nickel. Vessel is now being converted by States Marine Corp.

ratics of basic rock occurring within the ore column. At this point some 5000 gpm of water will be added, and the undersize material passed to log washers to break up lumps or mud balls. Subsequent two-stage screening will remove all +20 mesh material.

The finished slurry, at 35 pct solids, will flow by gravity through a 24-in. concrete pipeline set on a uniform grade of −1 pct and running about 14,000 ft to the head end of the process plant.

Processing

Briefly, the ore slurry is fed to a battery of autoclaves where it is mixed with sulfuric acid. The autoclaves are huge—about 40 ft in height and weighing 106 tons each, exclusive of brick lining. The autoclaves, which operate under elevated temperatures and pressures, will put into solution almost all of the nickel and cobalt in the incoming slurry. After thickening and washing, the acidity of the solutions will be adjusted and a precipitate of nickel-cobalt sulfide obtained by adding hydrogen sulfide.

The concentrate, containing about 55 pct Ni and 5 pct Co, will be transported as a slurry by tank trucks to the port area. There it will be pumped from storage to rubber-lined tanks on board a unique sea-going carrier, which will be discussed below.

Much of the total plant area will be devoted to thickeners. Two of 325-ft diam will accommodate incoming slurry from the mine. In the washing section of the plant there will be six acid-resistant thickeners of 225-ft diam. The neutralization circuit will include two 140-ft units, and four of slightly smaller size will be used in the sulfide circuit. Aggregate surface area of these thickeners will be 447,000 sq ft or slightly more than 10 acres.

In the plant, required chemicals will be manufactured by three separate package-type units: a hydrogen plant using LPG as a raw material and producing 1.5 million cu ft of hydrogen per day; a hydrogen sulfide plant with a daily liquid capacity of 60 tons—the largest plant of this type ever built; and a 1300-tpd sulfuric acid plant producing 98 pct acid—this will rank as one of the world's ten largest acid plants.

Special Cargo Vessel: A converted Liberty ship will act as a tanker for both concentrates and chemicals, operating in a shuttle service between Port Nickel, La., and Moa Bay, Cuba. On the southbound run it will accommodate about 5800 tons of molten sulfur in insulated tanks plus 140 tons of LPG in cylindrical deck tanks. On the northbound run it will carry about 2500 tons of nickel-cobalt slurry in eight rubber-lined tanks. The slurry tanks, 18 ft diam and 18 ft deep, will be arranged in two groups of four tanks each. The nickel-cobalt slurry —at 65 pct solids—will be pumped into the vessel tanks and allowed to settle during the voyage. Each group of tanks will be equipped with an agitating device which will go into action shortly before the vessel docks at Port Nickel. Thus, the settled concentrate will be re-slurried so that it can be pumped again from the vessel to shore tanks at the refinery.

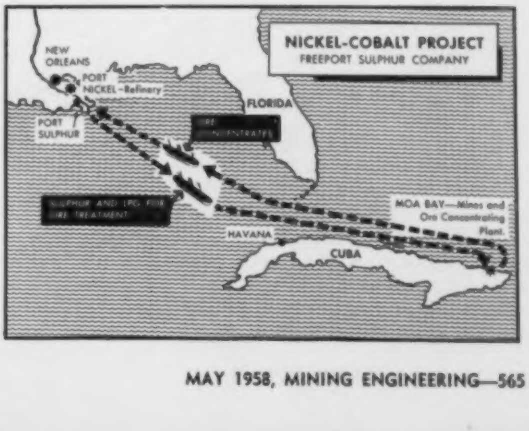
Port Nickel Refining Facilities

Port Nickel, where refinery construction is now underway, lies about 10 miles south of New Orleans on the Mississippi River. The refinery is being placed in Louisiana, rather than near the mining and concentrating facilities in Cuba, in order to keep down capital and operating costs and to permit effective competition with existing nickel sources. The refining process, for example, will require 25,000 tons per year of anhydrous ammonia, which in the Gulf Coast region is produced in quantity from an ample supply of cheap natural gas. Natural gas in the quantities required is not available in Cuba.

The refinery will process the sulfide concentrate to nickel and cobalt powder of high purity. The metals will also be briquetted, depending on customer needs, and some nickel and cobalt chemicals may be marketed.

The Moa Bay-Port Nickel project will be in production in the summer of 1959, contributing annually some 50 million lb of nickel and 4.4 million lb of cobalt to the markets of the Free World. Together with expansion at Nicaro, the project will boost Cuba into second place behind Canada in world nickel production and provide the largest source of cobalt in the Western Hemisphere.

Apart from the obvious benefits to this country of having a new source of these strategic metals close at hand in a friendly country, it is also hoped that this largest privately financed industrial venture in Cuba's history will be only the beginning of that country's development as a mining center of world importance.



Semi-Automatic Hoist at Copper Queen

A SEMI-AUTOMATIC hoist has been installed at the 2966 station of the Copper Queen mine, since neither the bulk of supplies handled nor the number of men engaged in developing the 3100 level justifies the constant attendance of two cagers and two hoist operators.

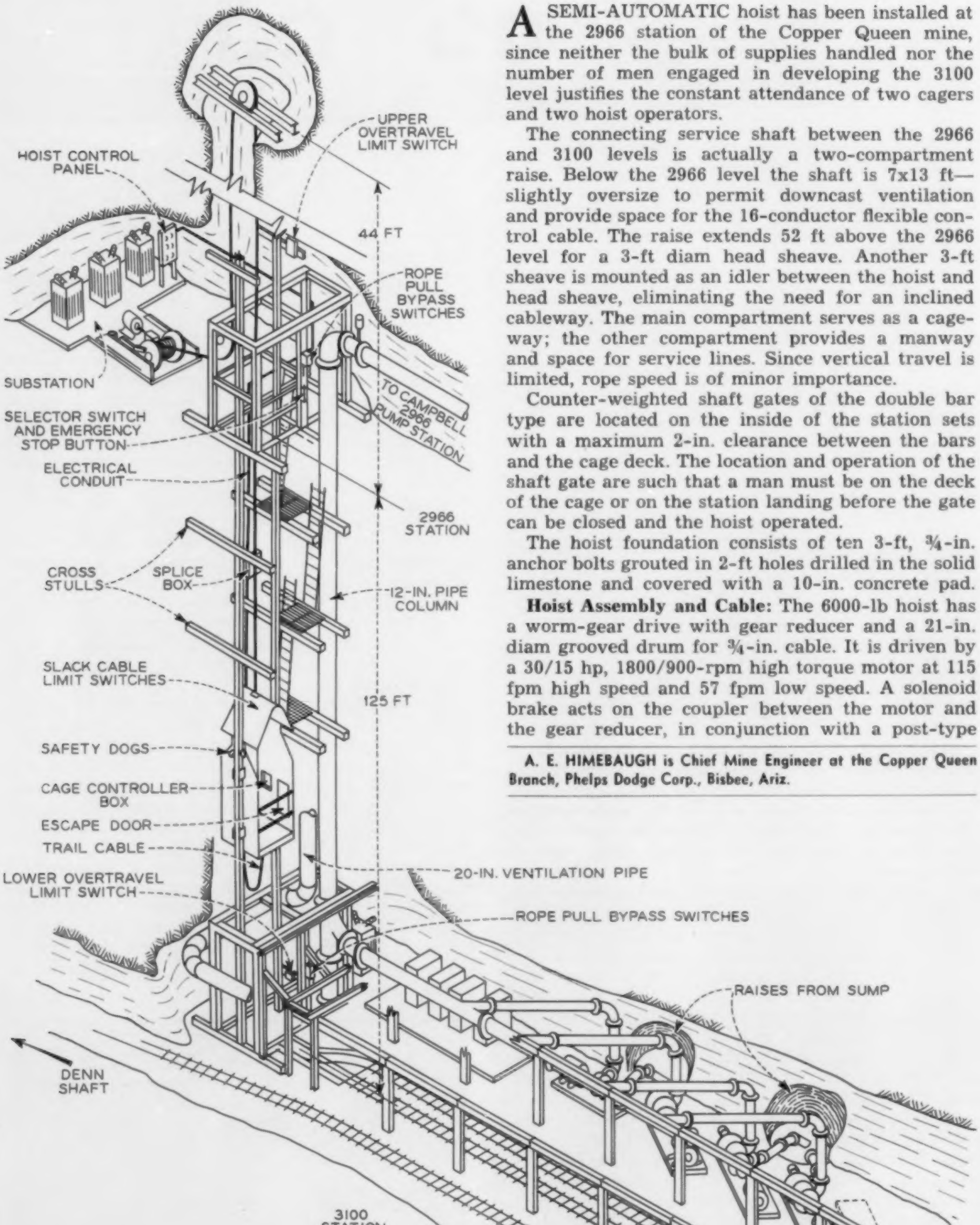
The connecting service shaft between the 2966 and 3100 levels is actually a two-compartment raise. Below the 2966 level the shaft is 7x13 ft—slightly oversize to permit downcast ventilation and provide space for the 16-conductor flexible control cable. The raise extends 52 ft above the 2966 level for a 3-ft diam head sheave. Another 3-ft sheave is mounted as an idler between the hoist and head sheave, eliminating the need for an inclined cableway. The main compartment serves as a cageway; the other compartment provides a manway and space for service lines. Since vertical travel is limited, rope speed is of minor importance.

Counter-weighted shaft gates of the double bar type are located on the inside of the station sets with a maximum 2-in. clearance between the bars and the cage deck. The location and operation of the shaft gate are such that a man must be on the deck of the cage or on the station landing before the gate can be closed and the hoist operated.

The hoist foundation consists of ten 3-ft, ¾-in. anchor bolts grouted in 2-ft holes drilled in the solid limestone and covered with a 10-in. concrete pad.

Hoist Assembly and Cable: The 6000-lb hoist has a worm-gear drive with gear reducer and a 21-in. diam grooved drum for ¾-in. cable. It is driven by a 30/15 hp, 1800/900-rpm high torque motor at 115 fpm high speed and 57 fpm low speed. A solenoid brake acts on the coupler between the motor and the gear reducer, in conjunction with a post-type

A. E. HIMEBAUGH is Chief Mine Engineer at the Copper Queen Branch, Phelps Dodge Corp., Bisbee, Ariz.



Proves Safe and Economical

by A. E. Himebaugh

drum brake operated by an 800-lb thruster mechanism. Two chain-driven rotating cam-type geared limit switches and a centrifugal overspeed complete the mechanical assembly.

The ¾-in. 6x19 hoist cable overwinds from the drum under the idler sheave to the head sheave and is attached to the king bolt by a zinc-filled open socket. A safety clamp on the cable just above the socket is attached by a chain to the crosshead as a precaution against failure of the cable socket. The drum has a single lap capacity of 175 ft, and with 6½ turns of spare cable on the drum, cage travel for normal operation does not require a second lap. With certain modifications, the standard mine cage —with safety dogs, hinged bonnet, and gate—has been adapted for semi-automatic hoist operation.

The hoist control panel includes a main line air circuit breaker connected to a magnetic reversing contact panel mechanically and electrically interlocked to control the direction of the two-speed motor, which in turn is controlled by a two-speed contactor panel that is also mechanically and electrically interlocked. The solenoid brake on the motor shaft and the thruster brake on the drum are controlled by a brake contactor on the panel.

Switches: Three pistol-grip operated selector switches control the hoist's direction of travel from the cage or from either station. These switches are arranged to be spring-returned to the *off* position from either the *hoist* or *lower* position to give deadman control. Running lights plainly visible on each station indicate whether or not the hoist is in operation; however, the circuits in these selector switches are so arranged that the first switch operated will disconnect the circuit to the other two selector switches. *Emergency-run* maintaining-type pushbuttons are mounted above each selector to stop the hoist immediately when necessary—operations cannot be resumed from any location until the same button is reset to normal position. This permits positive shutdown of the hoist and is particularly useful when repair work is being done in the shaft or when it is necessary to use the emergency escape door as an exit to the manway compartment.

Lever-type limit switches actuated by the shaft gate stop the hoist and set both brakes when the gate is opened for men to get on or off the cage. These two-circuit switches, adapted for spring return operation, have non-overlapping contacts, one normally open and the other normally closed. This arrangement allows the circuit to the selector switches to be opened, making operation of the hoist impossible from any of the selector switches. At the same time it closes a bypass circuit through rope-pull switches in front of the shaft by which the hoist may be operated at slow speed to set the cage on chairs or to handle long material slung under the cage.

Two limit switches of the same type, wired in series, are actuated by movement of the cage king bolt to prevent slack in the hoisting cable. A ½-in. downward movement of the king bolt will open the circuit to the lowering contactors and set both brakes, while the circuit to the hoisting contactors remains operative, permitting the cage to be hoisted but not lowered. This particular feature allows the cage to be placed on chairs without excess slack in the cable. The shaft gate must be open when the cage is placed on chairs and cannot be closed with the chairs in use.

One of the chain-driven geared limit switches mounted on the hoist is set to change the speed of the hoist automatically to low whenever the cage approaches within 3 ft of either station. This switch maintains the hoist at low speed for the maximum cage travel beyond each station and resets to high speed when the cage is 6 ft beyond the starting level.

The second geared limit switch assists in lowering long material suspended under the cage—when placed in the circuit via a bypass switch it prevents the cage from moving lower than 25 ft above the 3100 station.

Handling Material Under Cage: The bypass switch on the cage is thrown to the *off* position, placing the geared limit switch in the control circuit. With the shaft gate open the hoist is controlled at low speed with the rope-pull switch. When the material under the cage is hanging free in the shaft the gate is closed and a release signal is given on the call bell. The 3100 selector switch is then held in the *lowering* position until the cage comes to an automatic stop about 25 ft above the 3100 station. Beyond this point the cage cannot be lowered until the 3100 shaft gate is opened to permit operating the hoist at low speed from the rope-pull switches. After the suspended material is removed, the cage bypass switch is thrown to the *on* position, returning the hoist to normal operation. The shaft gate is then closed and the cage is released by a call bell signal.

Two heavy duty lever-type limit switches placed in the shaft to control overtravel are so mounted that they can be tripped by a metal cam on the side of the cage, confining downward travel to 3 in. below the 3100 station and the upward limit to some 25 ft above the 2966 station. In the event of an electrical or mechanical failure in the lower overtravel limit switch, the cage would be moving at low speed before striking the bottom of the 3-ft sump, which would immediately set the brakes on the hoist via the slack cable limit switches. As an added precaution, metal wedges are attached to the guides slightly above the upper overtravel limit switch. This would bind the cage in case it passed through the top limit, causing the motor to overload and the hoist to shut down.

A chain-driven overspeed switch on the hoist is set to permit speeds slightly exceeding 115 fpm, its chief function being to set the brakes should a mechanical failure occur in the worm gear drive.

Operation of the interlevel service shaft with its semi-automatic hoist has proved economical and safe. Posted operating instructions are easily understood and there has been little trouble in training development crews to operate the various controls.

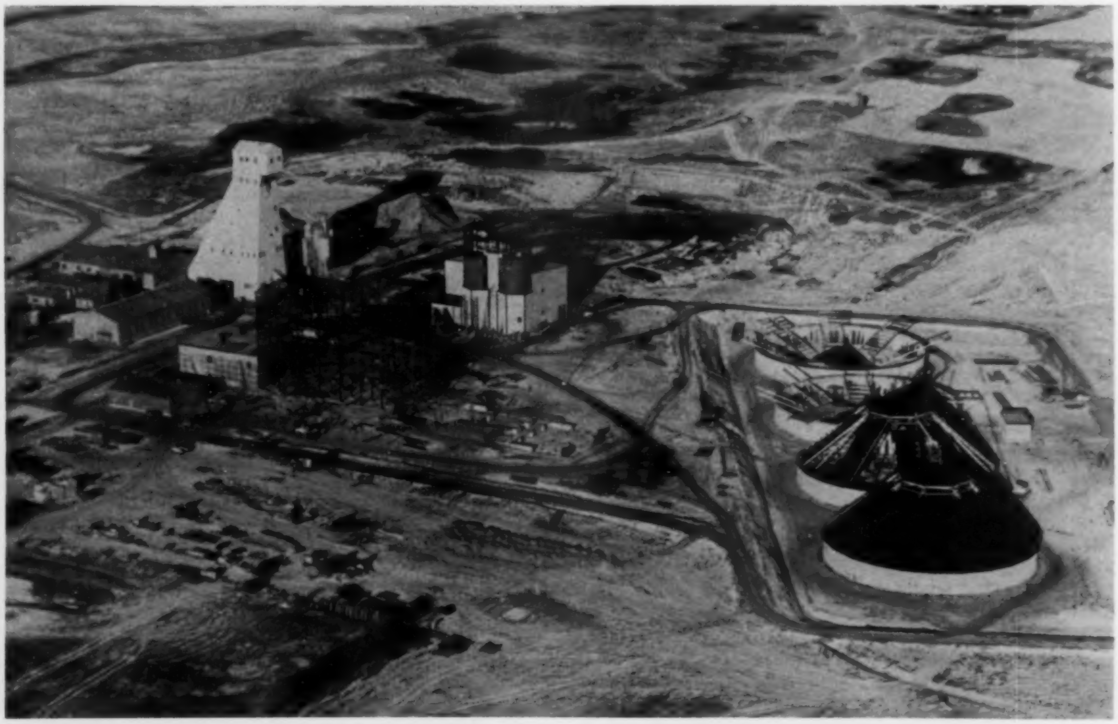
CANADIAN POTASH DEVELOPMENTS

With one shaft almost completed and another shaft being sunk, the scope of the Saskatchewan potash area is beginning to come into focus. Some 18 companies have reportedly leased more than four million acres to explore potash possibilities. PCA, farthest along, is located about 15 miles southeast of Saskatoon, and IMC has its project underway near Esterhazy in the eastern edge of the province. U. S. Borax and Chemical Corp. is also reported exploring the area.

The field lies in the middle Devonian geological formation which was probed by oil companies along the 200-mile area across the province. Extensive examination began after World War II and deep drilling was started a few years later.

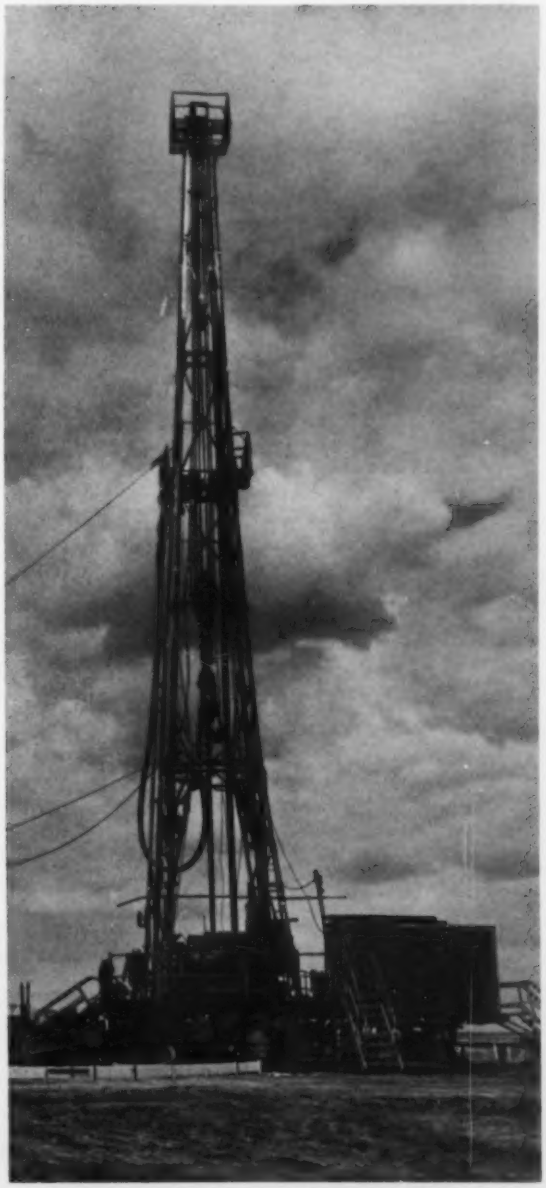
Unusual problems are posed by the more than 3000-ft depth of formation and weak and difficult overlying beds. The circular shafts of 16 or 18 ft diameter require freezing techniques for sinking through the upper levels.

PCA Speeds Completion of



The PCA mine and concentrator, on the southwest edge of Patience Lake, near Saskatoon, are undergoing final construction phases. Crushing plant is seen near center to right of headframe. Domed structures are ore warehouses, each to hold 20,000 tons.

INDEX MAP: Southern part of province of Saskatchewan shows outlined areas for principal potash land holdings. International Minerals & Chemical Corp. area shaded. Site of Potash Co. of America operations marked by arrow. Data courtesy IMC.



PCA spent more than a million dollars making 22 deep core tests over a two-year period. The 1954 exploration team is shown at work above.

Major Shaft

After more than ten years of investigation, exploration, and drilling, Potash Co. of America chose to develop an area about 15 miles southeast of Saskatoon. Thorough drilling showed a large potash deposit of a higher grade than that in the Carlsbad district and one with good mineable thickness. Despite the attractiveness of the deposit, the more than 3000-ft depth, water-bearing sedimentary beds above it, and possibly weak overlying structures presented serious mining problems.

Shaft sinking called for a ring of drillholes to freeze the ground throughout the water-bearing area and the required shaft was a major project in itself. There were, however, related favorable aspects.

To quote G. F. Coope, President of PCA, "An incentive for locating in Canada was the policy of the Dominion Government of attracting capital to development of the Canadian mining industry through an exemption from income tax during the first three years of operation. This policy enables investors to recover at least a very substantial part of their original investment during this three-year period, depending on operating efficiency. Since potash was not included in such tax-exempt mining ventures, your Company brought this to the attention of the proper Dominion officials who promptly recommended the inclusion of potash in the exempt classification. The Canadian Parliament, in line with their policy for encouragement of mining ventures, acted favorably on the recommendation."

Aiming for mid-1958 completion, the PCA shaft is now past the half-mile mark. The circular concrete-lined shaft has an inside diameter of 16 ft and will serve a concentrator plant for 4000 tpd capacity. It is topped by a 137-ft tall headframe. Overall scale of the project indicates an approximate $20 million cost for mine and concentrator with ultimate employment for approximately 200 men.

The distinctive dome-shaped warehouses, four in number, will hold 20,000 tons of product and will be unloaded by conveyor belts running underground to the dock area for shipment.

PCA points to a geographical advantage: its freight rates will be essentially the same as those from Carlsbad to most U. S. consumers. But, more importantly, "we shall have available a mineral deposit of tremendous extent and high quality, removing for all practical purposes, any concern about reserves for a century or so."

Potash Producer Looks to Canadian

IMC plans to diversify, increase muriate reserves

Left to right are IMC warehouse, head frame, and hoist house.

Reserves

with large high-grade Saskatchewan orebody

IN 1955 International Minerals & Chemical Corp. acquired a 600,000-acre withdrawal in southeastern Saskatchewan for a new mining venture. Concentrated drilling in the Esterhazy-Yarbo area some 125 miles northeast of Regina delineated the largest, highest-grade muriate orebody yet known, and a shaft pilot hole was begun in December 1956. Actual shaft sinking began early in 1957, and production is expected to be under way by 1960.

Growing diversification prompted this move. International's early operations in the Permian Basin, near Carlsbad, N. M., utilized 3000 tpd of ore and yielded only one product, muriate of potash. Today the company mines more than 12,000 tpd at Carlsbad and turns out six products for the agricultural and chemical industries. Starting with one ore, sylvinite, from which only one product could be profitably realized, International now mines a langbeinite level producing a double sulfate of magnesia from which potassium sulfate and magnesium salts can be obtained.

From Minerals to Chemicals: Minerals processing developments and a basic exchange technique have deflected a large part of the Carlsbad business to chemicals. The potash mine and refinery at Carlsbad have been integrated with a chemical plant at Niagara Falls.

But Carlsbad potash minerals are not as high-grade as they used to be, nor as easily mined. International's shift to a balance between muriate and chemicals has become important to the economics of the Carlsbad property, and for increased muriate tonnage the company has had to turn to new reserves.

This article presents information given in a talk by T. M. WARE, Administrative Vice President of International Minerals & Chemical Corp., at the Annual Meeting of AIME, February 1958.

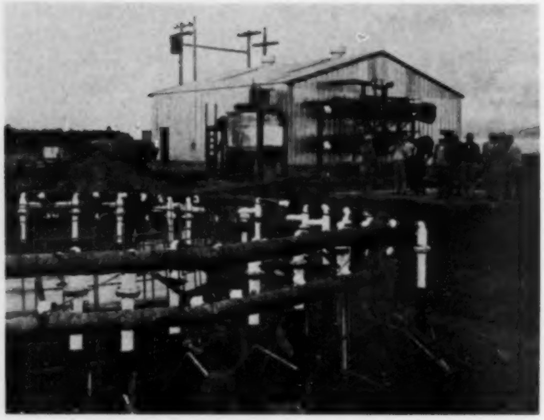
Saskatchewan Potential: Exploitation of the area in Saskatchewan was the final course. With the tremendous technical resources the corporation had developed, it was possible to confirm the advisability of the large investment required to produce muriate at this location. This decision was corroborated by several experts who were consulted as to quantity, grade, and feasibility of mining.

Unproven Risk: Promising as the Saskatchewan deposit appears to be, no one has yet mined it. There are many problems to be solved—conditions at the water horizons, variations of strata to a depth of 3300 ft, character of the ore itself, and sureness of cover or back. But the vast area of this latest discovery offers many advantages, and there are fewer uncertainties to face than there would be in another location.

Geology: The potash beds in the Province of Saskatchewan are components of salt beds 400 to 600 ft thick. The salt deposits extend over the area for at least 350 miles in length and 120 miles in width. The potash beds are probably not continuous over this area and are known to vary widely in potash content at different points, as proven by oil well drill logs and reports from other exploration efforts. The potash-bearing field is known to extend 25 miles to the east of International's location and northwest to the Alberta border 350 miles away.

Several hundred oil wells have been drilled in the potash-bearing area of Saskatchewan. In about 50 of these wells potash has been reported at 2760 ft or more below surface; however, the important intersections are all better than 2900 ft. Within the last five years at least ten companies have drilled a number of holes, especially for potash.

The potash beds occur near or at the top of a salt horizon of middle Devonian age called the *Prairie*



A network of pipes was used to freeze ground around shaft in early digging.

Evaporite Formations. In the potash areas this formation has an approximate thickness of 600 to 700 ft. The formation fingers out 50 to 75 miles northeast of the potash belt. The potash bed in International's area lies about 3100 ft below surface, with some 100 ft of salt cover. Overlying the salt for a height of about 1500 ft the rocks are largely limestone and dolomites. Overlying the limestones are sands, shale, and glacial till.

Major Features: Preparation for shaft sinking started last summer with freezing of glacial till to a depth of 320 ft and erection of temporary hoisting facilities. Sinking is currently progressing through the shale formation at a rate of 50 to 60 ft per week. The concrete-lined shaft, 18 ft in diam, will be sunk to 3300 ft.

A permanent hoist will be installed to take care of future expansion and permit flexibility in operations. Initial milling capacity will be 2000 tpd of ore. This will be expanded, as markets develop, to 6000 tons and more.

Total plant facilities are expected to cost more than $20 million. Operation is scheduled to begin about 1960. Progress to date has been very satisfactory, and construction schedules and costs are as planned.

Two railroads will service the mine. Canadian National already has a spur into the property, and Canadian Pacific will make connections before operations commence. The roads connect with major U. S. railroads and seaports, providing adequate distribution facilities for world-wide sales. Freight rates to the principal Midwest and Canadian consumer areas compare favorably with those from Carlsbad and Europe.

Future Markets: Although the new, competitive domestic operations, together with foreign imports, will materially increase the potash supply, there has also been a steady increase in demand. There is a growing plant food industry in the Midwest and Southwest, a pasture program in the Southeast and Southwest, and a trend toward use of plant foods with greater potash content.

At present there is evidence that potash production somewhat exceeds demand, but International's Canadian venture is designed to take care of anticipated domestic and foreign requirements, which are expected to increase by 700,000 tons in the next four years.

IMC's Corporate Growth

IMC's corporate growth began with production of phosphate minerals and the manufacture and distribution of plant foods to the farmer. In this early period there were more than 80 small companies mining phosphate rock in Florida. Screening was the beneficiation method, and all else was considered waste.

In 1926 IMC and Minerals Separation North American Corp. formed a joint company, Phosphate Recovery Corp., to develop nonmetallic mineral processing in the U. S. The phosphate industry grew rapidly as a result of extensive pilot plant work in the early days of this joint endeavor.

Potash ores that had been discovered in 1925 during oil drilling operations in the Permian Basin near Carlsbad, N. M., finally yielded during the late 1930's to a flotation process that separated sylvite from halite. Full-scale production of potash began in 1940.

In 1942 International set up its own minerals processing laboratories, and Phosphate Recovery Corp. was dissolved. Most recent of IMC's research centers is the minerals processing laboratory in Florida. With the mineralogical examination laboratory just completed, this facility is one of the finest of its kind in the U. S.

IMC has made important contributions in several areas of minerals processing:

- Advances in hydroseparation, notably slime separation and the sizing of phosphate and potash ores.

- Pioneer research in separating sylvite from halite, and in the phosphate industry major developments in the chief process for recovery of high-grade concentrate.

- Development of reagentized feed to make coarse separations of phosphate and potash ores on Humphreys spiral concentrators.

- Discovery of an unreagentized free-fall method to separate feldspar from quartz, potash feldspar from soda feldspar, phosphate from silica, and sylvite from halite.

During World War II International's processing knowledge was put to work on emergency development of a number of minerals—manganese, magnesium from langbeinite, fluorspar, serpentine to produce silica gels, and magnesium sulfate. None of these war-time developments, created as a contribution to the war effort, is in operation today. During the Korean War International included uranium-producing facilities in the plans for manufacturing phosphate chemicals at the new Bonnie plant in Florida. Although it is of doubtful economic importance today, in view of the tremendous stores of uranium that have since been discovered, this chemical process for liberating uranium from phosphate rock has been retained by the corporation.

Ore Transportation at San Manuel

Flexible haulage system moves large tonnage at high speed

by C. F. Cigliana

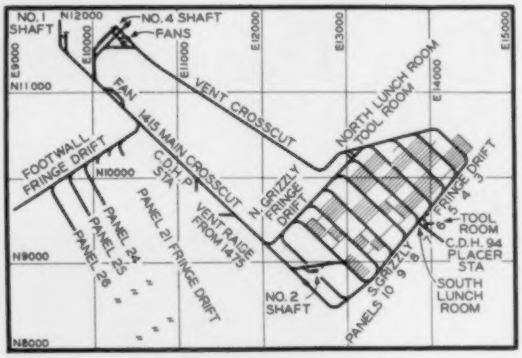
TO accommodate a large tonnage at high speed from a single level at San Manuel, a very flexible haulage system was designed to give maximum access to stoping areas, minimize delays, and provide for safety. With these requirements as a guide, the haulage was laid out as a simple double loop with one-way traffic of continuous pull. These loops consist of two parallel drifts 100 ft apart, center to center. Haulage drifts are numbered from north to south, the northernmost being the No. 1 drift. This holds true on both the North and South haulage loops.

Haulage drifts are connected at 1000-ft intervals with crossovers so that it is possible to bypass any given section that may be inaccessible. Two of these turnouts are double diamonds, one located on the approach to the rotary dumps at the hoisting shafts and the other on the departure from the dumps. The turnout on the approach or North haulage is 835 ft in front of the rotary dump, and the one on the departure, or South haulage, is 1058 ft from the dump. This type of turnout allows trains coming down either haulage drift No. 1 or No. 2 to be routed into either shaft and expedites movement by avoiding delays due to congestion in the dumping area. The double diamond on the return haulage loop facilitates returning empty ore trains to the panels.

The 1475 level haulage was developed by driving 5.29 miles of main haulage line and 5.79 miles of panel drift. Drifts are timbered with 10-ft caps and two 10-ft 5-in. posts. Most of the haulage was

C. F. CIGLIANA is General Mine Foreman, San Manuel Copper Corp., San Manuel, Ariz.

Double diamond in haulage drifts.



Plan of 1415 grizzly level.

driven with 12x12-in. treated timbers, but in some faulted areas 12-in. 53-lb steel H-caps were used. All turnouts in the system were driven with 165-ft radius curve using the 12-in. 53-lb steel caps. All caps are top lagged with 5-ft lengths of 3x6-in. lagging and sides of the drifts are laced with 5-ft lengths of 2x10-in. lagging. In the turnout areas where excessive weight and repair were anticipated the H-beams were reinforced to the equivalent of 90 lb. When two of these areas were grouted results were so satisfactory and the decrease of ground movement so evident that the grouting program has been expanded.

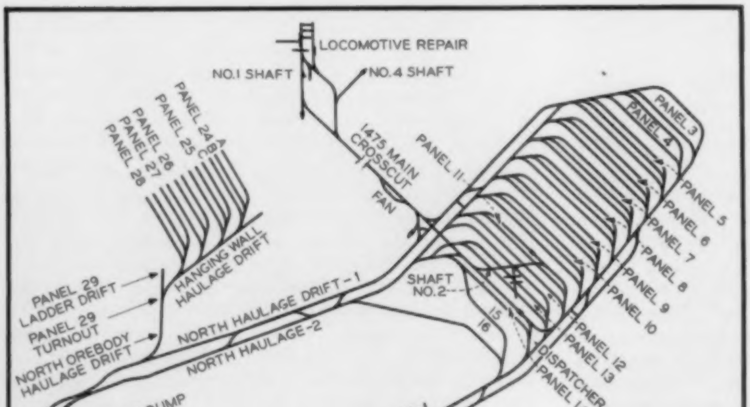
The 36-in. gage main line haulage tracks are laid with 90-lb rail using 6 x 8-in. x 6-ft treated ties on 18-in. centers, ballasted with 12 in. of 2-in. crushed granite. Track grade is 0.45 pct in favor of the load. Automatic switches are set in alignment by the front wheels of the locomotive of the loaded train as it leaves the panel. The operator on the empty train returning on the South haulage activates the spring switches electrically. All switch points are protected by guard rails.

The panel tracks were laid with 70-lb rail equipped with a permanently installed re-railer ahead of each block. Any cars derailed during loading are automatically replaced on the track as the train advances through this re-railer.

Although mine operations are on a three-shift basis, the blocks are drawn on a staggered basis for two shifts, leaving time for them to be free on the third shift for track maintenance and drift repair. The track is cleaned with one Eimco 21B deck mucker and one especially constructed Eimco 42 track cleaner, which draws power from the regular trolley line.

Haulage equipment consists of thirteen 23-ton locomotives and two 12-ton locomotives that operate from a 275-v d-c trolley line. Full voltage is maintained by three 500-kw rectifier stations in parallel, so that if any one station fails, power can be maintained by the other two. One station is located on the North haulage, one on the South haulage, and one at the hoisting shaft.

The 23-ton trolley locomotives (64 in. wide, 56 in. high, and 21 ft 6 in. long) are driven by two 120-hp motors centrally hung. This arrangement provides the balance necessary for best track performance



Plan of 1475 haulage level.

for long hauls at high speed. At both ends of the locomotive there are Willison automatic couplers, each equipped with an air-operated uncoupler.

All locomotives have three types of braking on all four wheels—air braking, hand braking, and dynamic braking—and are also equipped with over-speed and dead-man controls.

Control is set up for selective series or parallel operation of traction motors in either direction. Acceleration is obtained by moving the main drum clockwise, and dynamic braking by moving the main drum counter-clockwise from off position. The controller is equipped with a dead-man tip-up handle, which must be held down to apply power to the locomotive; if it is released the circuits are opened and power is removed from the traction motors. At the same time the emergency air brakes apply.

If the locomotive exceeds 15 mph the over-speed contact will automatically open, removing power from the traction motors, and brakes will be applied through the emergency air valve in either run or brake position. When motor speed has been sufficiently decreased, power can again be applied.

The hand brake is applied by a 12-in. wheel operating a square threaded brake screw. Air brakes exert pressure on the brake linkage in the same way as the hand brake. A pressure cylinder is connected to the standard hand-operated brake linkage, and the governor cuts the compressor into the circuit when the pressure is too low to be effective.

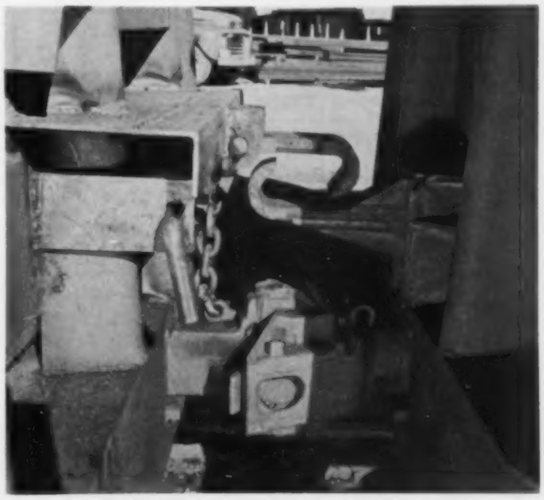
A standard ore train consists of fifteen 12-ton cars, each equipped with one stationary and one rotary coupling, as well as a local innovation—a safety coupling used to prevent cars from uncoupling in transit. The box-type steel cars have rubber-cushioned draft gear and are mounted on four-wheeled Timkin roller-bearing trucks carrying 14-in. diam gray chilled cast-iron wheels.

Trains are 285 ft long, and eleven 15-car trains are considered enough for a 30,000-ton operation. The entire haulage operation is controlled by a dispatcher, and clearance must be obtained by operators before motors or locomotives are moved into the haulage loops.

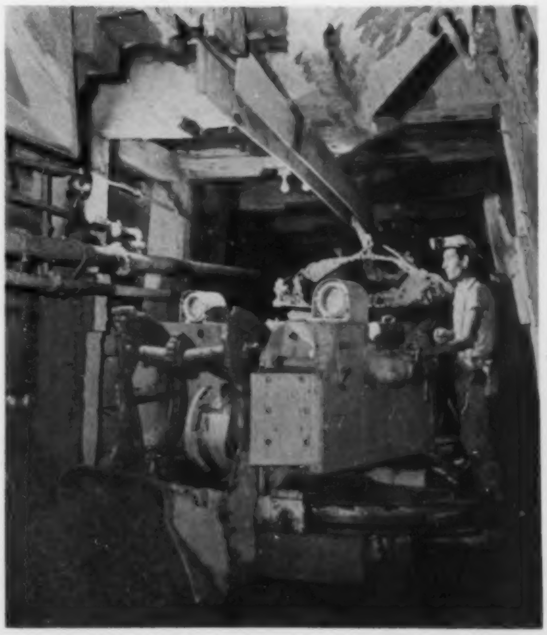
All haulage locomotives and 8-ton development motors have radio telephones. Phones on locomotives transmit signals by trolley wire to the dispatcher and other units. Battery motor telephones draw power from a dynamotor and transmit through an antenna to the trolley line. A block signal system, used in conjunction with the radios, is put in operation by the motorman as he brushes a low-voltage touch plate switch with his hand in passing. This touch plate is another device designed at San Manuel.

Draw and haulage operations are coordinated through the dispatcher by a paging system on 110-v a-c power, with speakers located at the blocks on the 1415 grizzly level and in the panels on the haulage. This gives two complete communication systems, one to move traffic and the second to feed the dispatcher with information on drawing operations.

There are three phases in ore transportation—loading, traveling, and dumping. In the first phase trains are loaded against the track grade to take all slack out of the couplings, making it easier and smoother to spot the cars under the loading chute. Cars are spotted under the chute by men at the loading station using hand-operated signal lights and are loaded from steel chutes. These chutes, which are practically free of ground support and may be described as floating, are installed on trunnions supported by the two caps of adjacent drift sets. The undercut guillotine door is operated up and down by an 8-in. diam air cylinder with a 36-in. stroke and passes through a slot in the bottom of the chute, held in guides at each side. The door has ¾x2x36-in. extensions to prevent the guides from filling with muck. Cylinder and door guides are supported by H-beam and angle iron which is bolted to the bottom of the chute slide.



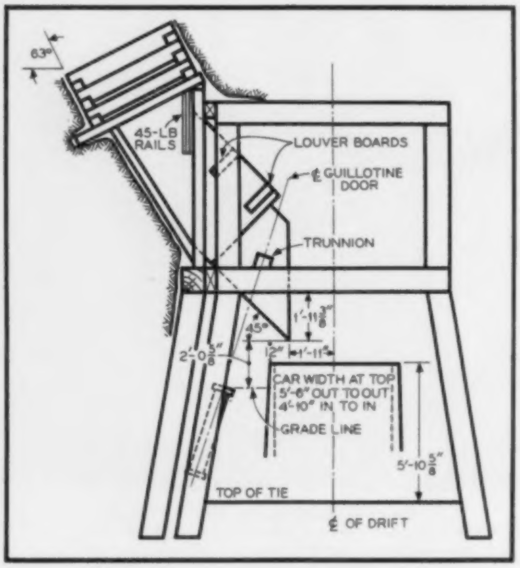
Safety coupling developed by San Manuel.



Eimco 42 track cleaner was modified to draw power from trolley line.

This type of chute, with its 36x39-in. opening, allows maximum freedom for barring or blowing out the chute mouth, while the positive undercut action of the door makes it practically impossible for a boulder to hang the chute open.

When the train is loaded the operator obtains clearance and hauling instructions from the dispatcher and proceeds into the North haulage, clearing the panel drift and closing the haulage block signals. He then observes posted speed limits and block signal procedure while traveling the haulage loop to the rotary dump. Cars are dumped three at a time in a tipple that rotates 180°. The ore is discharged into a 1500-ton concrete pocket lined with 60-lb rail, from which it is hoisted.



Loading chute for transfer raises.

Jeto bottom-dump skips empty into 5000-ton bins.

To avoid the hazard that may occur when especially wet ore is handled, skip loading is carried on by two men. Electrical signal lights are used to coordinate the operation. Ore drawn by the first man from the pocket into the measuring basket is controlled by gates of the undercut-guillotine type, which are operated by 16-in. diam air cylinders with 56-in. stroke. Ore is then discharged into the skips from the measuring basket by a second man who also sets into motion the semi-automatic hoisting cycle after the skip is loaded. Automatic controls take the skip from the loading position to the dumping position. Ore skips are run in balance.

The twin four-compartment 3A and 3B shafts were designed to provide high-speed, large-capacity hoisting. The conventional A-type head frames are 180 ft high on 195-ft centers. The compartments are 6 ft 6 in. x 7 ft in the clear. The No. 1 compartment is equipped with an auxiliary hoist and cage to handle personnel, maintenance supplies, and the spill pockets. No. 3 compartment is the manway, while compartments No. 2 and 4 handle the two 19.0-ton Jeto bottom-dump skips. These skips, equipped with hard rubber tires, travel on 6x8-in. steel guides at 3000 fpm. They discharge into 5000-ton surface ore bins.

Ore is hoisted by two of the most powerful hoists in use today. These hoists are geared to two 3000-hp, 600-v d-c motors. Each is driven by a motor-generator made up of a 4000-hp d-c, 2300-v induction motor, driving two 2500-kw d-c generators, with 50-ton flywheel for 80 pct power peak equalization. The dual cylindrical drums on each hoist have a 116-in. face and a 15-ft diam and wind 3600 ft of 2¼-in. rope (6 by 19) in two layers. A single hoist is capable of hoisting 1000 tph. To operate the haulage system a typical shift is organized as follows:

Haulage shift boss	1
Jigger boss	1
Dispatcher	1
Rotary dump operator	4
Skiptenders	4
Locomotive operators	11
12-ton locomotives	2
Chute blasters	11
Chute tappers	11
Clean up	1
Total	47

This organization has proved capable of hauling a maximum of 13,124 tons in a single shift; the maximum for three shifts is 35,321 tons. Average ore tonnage per manshift on haulage totals 220.0.

A breakdown of the time consumed in the three phases of the haulage operation shows the loading time to be 24.43 min, hauling time to the rotary dumps 12.94 min, dumping time 4.64 min, and return trip 12.12 min. This totals 54.13 min per train, and each train averages 6.4 trips per shift.

Acknowledgments

Acknowledgment is made to the management of San Manuel Copper Corp. for the sketches, photographic reprints, and information made available for reproduction.

Estimating Data for Open Pit Haulage Trucks

by H. A. Wilmeth

IN 1955, before planning an accelerated stripping program, Chino Mines Div. began an engineering study to improve data for estimating truck haulage costs for any future haulage layout. The study aimed to develop: 1) significant unit costs, 2) a method of estimating travel time from which truck needs and future stripping rate could be determined, and 3) yardsticks of performance to measure haulage efficiencies.

It was suggested that to provide significant unit costs, expense accounts should offer management two types of cost control information—unit cost yardsticks with which monthly unit costs could be compared and unit costs for estimating future expenses for any haulage layout.

These two general uses of cost accounting provide clues to proper expense breakdown. Both instances require unit costs that remain virtually constant regardless of road layout. Unless a unit cost is constant for any haulage layout, how can it be used to estimate costs for a different operating condition?

A list is made of every truck expense. Each separate expense is classified according to its source. Costs originating or resulting from the same basis are included in the same category:

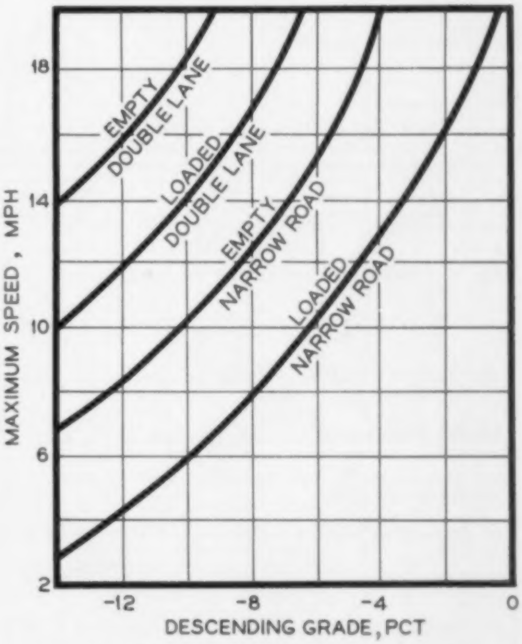
For yardstick purposes, the unit cost expression in this table is considered constant for a given level of efficiency as explained by the following analysis:

1) Daily costs, or fixed annual costs, are costs of depreciation, taxes, interest on investment. These are fixed for a given fleet. The unit cost in independent of the hours operated or the days the operation is scheduled to work. Unit cost is entirely dependent on the number of calendar days and is unchanged except by additions to the fleet, increased tax rate, etc.

2) Shift costs, or costs per operating day, are those resulting from the standard shift assignment of crews for operating, repairing, and servicing the truck fleet. Such unit costs are constant until the standard labor force or the wage rate is changed.

3) Hourly operating costs include costs that result from operating the fleet. They are affected by operating delays and to some extent by duration of haul. However, for a given efficiency (constant delay time), the unit costs are considered fixed, since overall operating time remains unchanged. For example: Costs for a 30-min. haul on a 6 pct grade and a 30-min haul on a 2 pct grade are about the same if the overall delay is the same per shift. This is approximately true for most hauls because the hourly costs are dependent on the power output per hour operated, and if a given haul road permits the truck to operate near maximum output for at least half the haul distance, the hourly operating costs are approximately the same. It is possible, of course, that there may be some hidden cost-incurring or cost-reducing condition such as the fleet's condition of repair, delay time, etc.

H. A. Wilmeth is Mine Engineer, Chino Mines Div. of Kennecott Copper Corp., Santa Rita, N. M.



Maximum haulage truck speed on descending grades. Based on curves from *Cost of Hauling Logs by Motor Truck and Trailer* by James J. Byrne et al. Checked by observations of haulage trucks on two descending grades at Chino Mines, one narrow and one double lane.

4) Mileage costs for equal road surface conditions do not vary, since tire wear depends on ground contacts and is therefore a constant cost per mile.

Total estimated haulage cost for a future condition is obtained by multiplying the historical unit costs by the number of units involved, i.e., unit hourly costs times total hours, plus daily costs times

(Continued on page 580)

Unit Cost Expression	1 Cost Per Day	2 Cost Per Shift	3 Cost Per Hour	4 Cost Per Mile
Specific cost sources	Depreciation, taxes, interest on investment	Operators wages Repair crew wages Service crew wages	Fuel Oil Repair parts	Tires

1. LOADING AND HAULING CONDITIONS

a. Shovel: 4161______ No. 33 (2½-yd)______

1 side______ 2 sides______

b. Spotting 1 back up______ 1 fwd. and 1 back up______

c. Digging: good______ fair______ poor______

d. Average shovel swing: 60°______ 90°______

e. Dumping: on dump______ on ramp______

f. Road description

Road Section	Distance, ft	Grade, pct	1 or 2 Lanes

2. TRUCK CYCLE TIME

a. Travel time (from graphs)

Sec. Road	Start from 0 mph	Distance, Accelerating	Distance, Sustained Speed	Distance, Decelerating	Distance at Speed Governed by Road Conditions (loaded)	Distance, Approach and Spotting	Speed, mph Initial-Final	Time, Seconds

Total truck travel time______sec

b. Truck loading time under shovel (from chart): ______sec

Total ______sec

3. SHOVEL TIME TO LOAD 1 TRUCK (from chart): ______sec

4. TRUCKS REQUIRED (Item 2 divided by Item 3): ______sec

5. TONNAGE PER SHIFT:

a. Rounding off Item 4 by reducing to next whole number or truck (some shovel delay—no truck delay):

$$\frac{\text{No. trucks x min. loading time/shift x 26 tons/load}}{\text{sec. trip time/load}} = \_\_\_\_\_\_ \text{tons}$$

b. Rounding off Item 4 by increasing to next whole number or truck (no shovel delay—some truck delay):

$$\frac{\text{min. loading time/shift x 26 tons/load}}{\text{sec. loading time/load}} = \_\_\_\_\_\_ \text{tons}$$

(Instructions numbered to correspond with the parts of the estimating sheet)

1. Determine the expected loading and hauling conditions. Check the expected operating conditions at the top of sheet in the spaces provided. Break the haul road into the sections having uniform grade and enter the distances, grades, etc., in the table for road description.

2. Determine the total truck cycle time by determining the time for each travel element of the trip. Refer to the "Performance Graphs, 25-Ton Haulage Trucks" to obtain travel time on sections of haul roads which do not limit either attaining average maximum speed (20 mph) or utilizing maximum power. Refer to "Curves of Maximum Speed of Descending Grades for Haulage Trucks" to obtain average of expected speeds on descending grades. Drivers adjust the speed of the truck to the safe descending speed before reaching a steep grade. If the segment of haul road approaching a steep down grade is short, use the safe descending speed on approaching down grade for the speed on the entire approach segment.

a. Begin the computation of trip time where the loaded truck is ready to leave the shovel.

(1) Enter 2 sec on the first line of the "travel time" table because the truck would be starting from 0 mph (see note on acceleration graph).

(2) Determine time and distance required to accelerate to maximum attainable speed for the grade of the first section of road by referring to the "accelerating-loaded" curves. Follow the curve for the given grade from 0 mph to either the distance at which average maximum speed is attained or the distance equal to the length of the section of the road, whichever comes first.

(a) If the distance required to accelerate to maximum speed is greater than the length of the section of road being considered, enter in the travel-time table the speed that can be attained and the time elapsed in traveling the entire distance of this section of the road, as well as the length of road traveled.

(b) If the maximum speed is reached before the full section of road is traveled, enter in the travel-time table the time lapse and distance traveled to reach this speed, as well as the speed attained. Then determine the time to travel the remaining segment of this section of the road by referring to the "sustained-speed-loaded" curves, and enter distance, speed, and time on a line of the travel-time table.

(3) Determine the distance, speed, and time data for the succeeding sections of the haul road. If the entering speed onto a different section of the road (different grade) is below the maximum attainable for that grade, the truck will accelerate; it will decelerate if entering at a speed higher than it can sustain.

(a) Locate the entering speed onto the new grade on the graph curve that corresponds to the new grade and note the time and distance. Follow along the curve to either the average maximum speed or the additional distance equal to the length of this section of the road, whichever comes first.

(b) Follow instruction in 2. a. (2) (a) and (b) above for determining elapsed times, distances, and speeds for segments making up the entire section of the road.

(4) Choose the time for slowing, spotting, and dumping (or slowing and spotting at shovel) for the expected operating conditions, i.e., dumping from ramp or dump (spotting at shovel with 1 back up, or 1 forward and 1 back up). Slowing distance when approaching to dump (or shovel) is assumed to be 150 ft in all cases and is subtracted from the final section of road to the dumping (or loading) location before computing the time to travel the approach segment. The time required to travel the final leg (less 150 ft) is computed as for other road sections where the truck operates at maximum speed or performance.

3. Determine the time that the truck is under the shovel from the accompanying table, "Truck Time Under Shovel."

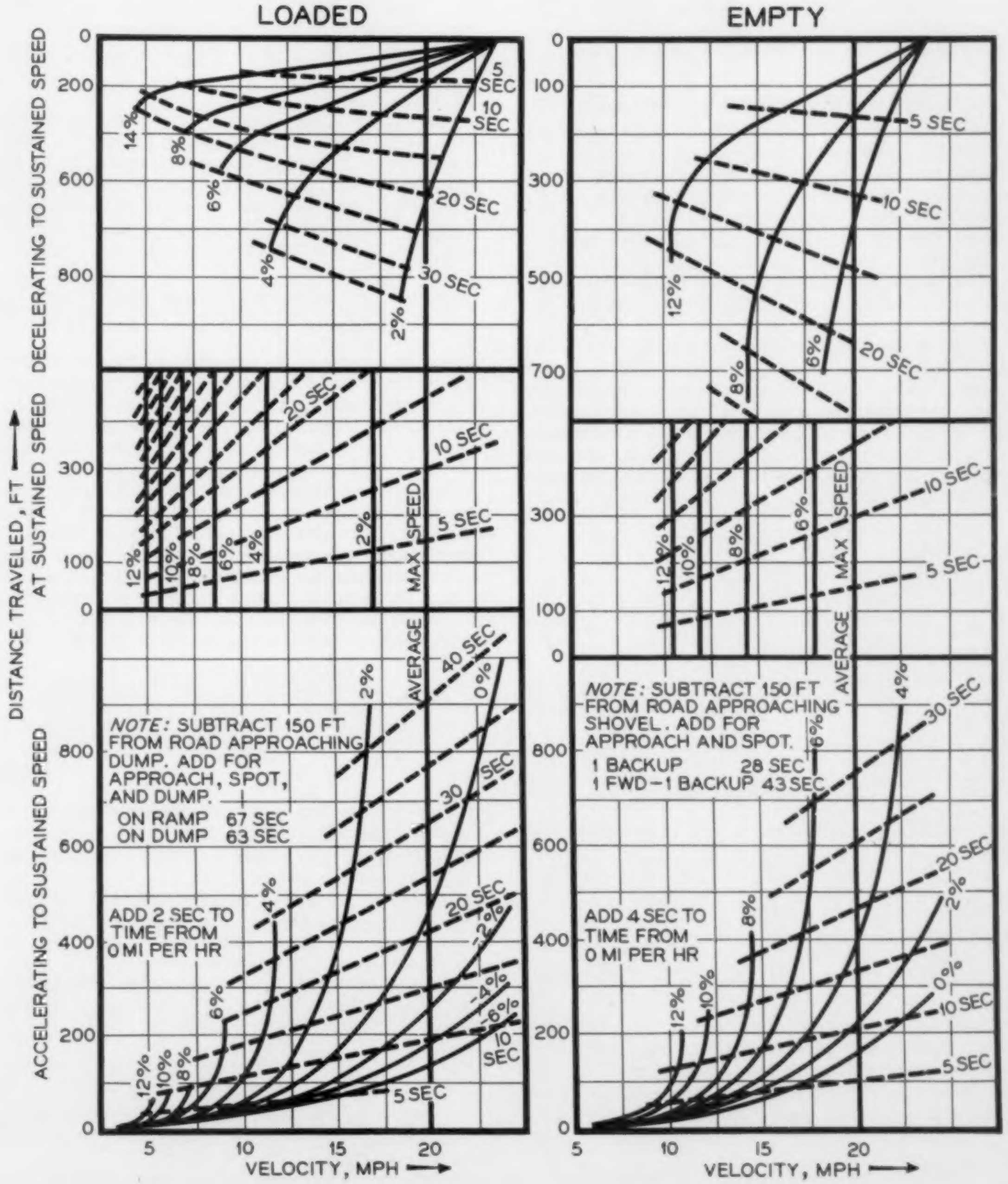
4. The number of trucks required for a given operation is determined by dividing the shovel time to load one truck into the total truck-trip time.

5. The expected tonnage per shift is determined for two conditions:

a. When there is a fraction more trucks than needed to cover the shovel based on total available shovel operating time, time required to load one truck, and tonnage per truck-trip.

b. When there is a fraction of a truck less than needed to completely cover the shovel based on total truck-operating time, time per truck-trip, tonnage hauled per truck-trip, and the number of trucks in operation.

Performance graphs for 25-ton haulage trucks. Graphs are based on average truck.



Shovel Time to Load One Truck*

Digging	Spotting—1 or 2 Sides (Average Swing)	5-Yd, Sec	2½-Yd, Sec
Good	2	72	
Good	1	95	
Fair	2		
Fair	1		
Poor	2		
Poor	1		213

* Times not shown, not yet determined. Times shown are times required to load one truck completely.

Truck Time Under Shovel*

Digging	Average Swing	Spotting	5-Yd, Sec	2½-Yd, Sec
Good	60°	One side	46	
Good	90°	One side	95	
Good	60°	Both sides	72	
Good	90°	Both sides	95	
Fair	60°	One side		
Fair	90°	One side		
Fair	60°	Both sides		
Fair	90°	Both sides		
Poor	60°	One side		
Poor	90°	One side		213
Poor	60°	Both sides		
Poor	90°	Both sides		213

* Times not shown, not yet determined.

(Continued from page 577)

total days, plus mileage costs times total miles, etc. The total hours, shifts, and days involved in a contemplated job is dependent on time per trip. Therefore a method for estimating trip time is needed.

Estimating Trip Time for Any Given Layout

The trip time for a haulage layout must be known before the number of trucks required and the resultant truck haulage costs can be estimated. Total trip time is the time required for the sum of the following separate operations: loading, travel loaded, spotting and dumping, travel empty, spotting at the shovel, and delay time. Time study is used for determining the time required for loading, spotting, and dumping, spotting at the shovel, and delays.

Average performance graphs are developed for estimating travel time, empty and loaded, under varying road conditions with a combination of time study and kinetic energy formulas. Time study is used to check actual acceleration and deceleration rates on known grades to determine the average power of the trucks in the fleet by the formulas below (Eqs. 1-3), where:

W = gross weight of vehicle
V_i = initial velocity, fps
V_f = final velocity, fps
V_a = average velocity, fps
P_t = power of truck, ft-lb per sec
G = grade resistance in decimal
R = rolling resistance (0.021)
T = time increment, in seconds, to accelerate from V_i to V_f

Time of acceleration:

$$T = \frac{W\,(V_f^2 - V_i^2)}{2g\,[P_t - W\,V_a\,(G + R)]} \qquad [1]$$

Time of deceleration to reach maximum sustained speed:

$$T = \frac{W\,(V_i^2 - V_f^2)}{2g\,[W\,V_a\,(G + R) - P_t]} \qquad [2]$$

Maximum sustained speed:

$$V_a = \frac{P_t}{W\,(G + R)} \qquad [3]$$

These computations are useful only if road conditions permit the truck to develop and operate at maximum performance. Road layouts must therefore be properly super-elevated and provide sufficient road width, and road surfaces must be good.

Ton-Time, Yardstick for Future Efficiencies

Consider the following two haulage layouts, having 0.5-mile and 1-mile lengths, respectively:

Haul Dist., Miles	Shovel Loading, Sec	Travel Loaded, Sec	Spotting and Dumping, Sec	Travel Empty, Sec	Spotting at Shovel, Sec	Trip Time, Sec
0.5	60	120	25	85	20	310
1	60	240	25	170	20	515

Consider the resultant ton-time and ton-miles of the above two haulage layouts, assuming an overall delay of 2 hr per shift for each haul:

Haul Dist., Miles	Trip Time, Sec	Tons per Trip	Trips, No.	Tons per 6-Hr Operating Shift	Ton-Seconds	Ton-Miles
0.5	310	25	69	1725	534,700	862.5
1	515	25	41	1025	527,800	1025.0

The ton-time per truck shift is considered constant for a given level of efficiency, $xy = C$. Improper truck operation, improper number of trucks scheduled, and a change in actual operating time are the factors that cause the ton-time per truck shift to vary. This suggests a method for measuring efficiency of the truck fleet under any given haulage layout:

$$E = \frac{\text{actual ton-time per shift}}{\text{maximum possible ton-time per shift}} \qquad [4]$$

where actual ton-time per shift = the actual tons hauled times the acceptable standard trip time (as determined from trip time graphs) divided by the actual shifts worked. The maximum possible ton-time per shift = capacity of the truck multiplied by the total working time available per shift.

The ton-time factor is useful in estimating haulage requirements in the development of mining programs using either trucks or trains. First, it is necessary to determine the round trip travel time, including delays, for both ore and waste, from every area in the mining program. The total haulage requirement for either ore or waste, based on past performance records, is expressed by Eq. 5:

$$\text{Haulage shifts required} = \frac{(\text{ton}_1\ \text{time}_1) + (\text{ton}_2\ \text{time}_2) + \ldots\ (\text{ton}_n\ \text{time}_n)}{\left[\dfrac{(\text{ton}_{h_1}\ \text{time}_{h}) + (\text{ton}_{h_2}\ \text{time}_{h_2}) + \ldots\ (\text{ton}_{h_n}\ \text{time}_{h_n})}{\text{total shifts}}\right]} \qquad [5]$$

where ton_1, ton_2, ton_n = tons of ore (or waste) to be mined from location 1, 2, etc.;
time_1, time_2, time_n = round trip travel time, including delays from area 1, 2, etc.;
ton_{h_1}, ton_{h_2}, etc. = actual tons hauled from the various areas in the past;
time_{h_1}, time_{h_2}, time_{h_n} = round trip travel time, including delays for the areas mined;
the total shifts = the actual number of shifts for the haulage units worked over a known period of time.

Summary

In summary, the following steps are outlined, as a possible approach to better cost control for a truck haulage operation:

1) Develop an expense breakdown by which constant unit costs yardsticks may be obtained to compare monthly cost variations.
2) Develop data for estimating standard trip travel time.
3) Develop standard performance factors based on ton-time.

Acknowledgment

The author expresses appreciation to J. J. Brubaker, Chino Mines Div. industrial engineer, for his assistance and direction and also thanks D. Schmidt and W. McKee, Chino industrial engineers, who did most of the field work.

Fine Grinding at Supercritical Speed

by R. T. Hukki

IT is no great exaggeration to say that present grinding practice and economics are largely determined by lining design. A record of outstanding liner wear can be achieved with any liner surface pattern that will positively lock the outer layer or layers of grinding media. With no slippage, lining wear is bound to be slight. At the same time, popular practice calls for tumbling loads of about 50 pct of mill volume to obtain maximum grinding capacity. Innumerable parallel grinding investigations have verified that optimum speed for such a mill lies within 70 to 85 pct of theoretical critical speed. If the mill is speeded up to 100 pct of critical, little or no grinding can be accomplished.

Earlier Work on Supercritical Grinding: First investigations concerning grinding at supercritical speeds seem to be very old. Remarkable work on the subject has been performed by White,[1] and his experiments have been described and summarized by Richards.[1] White's contributions seem to have passed unnoticed by Fahrenwald,[2,3] whose extensive experiments have been well presented, yet apparently very little appreciated. Additional work on grinding at supercritical speed has been reported, e.g., by Lewenson and Tscherny,[4] USSR; Anselm[5] and Grunder,[6] Germany; and Rose and Evans,[6] Great Britain.

Subcritical and Supercritical Speeds: In the formula of the critical speed given in the textbooks of mineral dressing, no factor indicating the coefficient of friction is generally included. If this factor = 1.0, which is equivalent to grinding conditions in a mill provided with heavily ribbed lining, the formula of the critical speed holds as such and grinding is possible at subcritical speeds only. In a mill equipped with a smooth or relatively smooth lining, the numerical value of the friction factor in the denominator of the formula becomes <1.0, indicating that grinding at supercritical speeds should be possible in such mills. It has been recently shown by the author[7] that a wide supercritical speed range will become available for grinding—and especially for fine grinding—if the basic conditions within the mill have been selected properly. Mathematical analysis of mill dynamics at supercritical speeds[7] has indicated that the mill speed may be increased if:

1) total mass of grinding medium decreases,
2) mass of the individual grinding piece increases, and
3) the coefficient of friction between the outer layer of medium and the mill lining decreases.

It is obvious that the mass of the individual grinding piece will be affected by its shape and by its specific gravity. The coefficient of friction decreases with:

1) increasing smoothness of liner surface,
2) increasing roundness of the grinding piece,
3) increasing fineness of material to be ground,
4) decreasing pulp density, and
5) decreasing hardness (abrasiveness) of the mineral to be ground.

In a mill equipped with heavily ribbed lining, practically no size reduction will take place between the lining and the outer layer of tumbling medium, because slippage is prevented. In the overwhelming majority of today's mills the grinding accomplished is by virtue of cataracting and/or cascading media with some action within the tumbling charge. Subcritical speeds only can be applied.

In grate-type or peripheral discharge mills equipped with a smooth lining a tumbling load of any kind of common medium occupying about 50 pct of mill volume will behave in such a way that practically no slippage will take place. This has been verified in experiments run by the author in the laboratory and in pilot plant mills[7] equipped with smooth lining. Again, the operation is limited to the subcritical range.

In a mill with a smooth lining, grinding will be possible either at subcritical speeds or within a wide supercritical speed range as soon as the basic requirements for a desired speed are fulfilled.

In a mill operated at supercritical speed, any point on the liner surface proceeds at a speed greater than that indicated by the formula of the critical speed, while any grinding piece situated in the outer layer of the medium against the lining proceeds in the same direction at a speed less than that indicated by the critical speed. This speed difference produces a very effective attrition grinding zone between the liner surface and the outer layer of the medium. The share of attrition grinding of the total grinding accomplished increases rapidly with increasing speed in the supercritical speed range.

The smooth surface of the mill lining may be well illustrated by the surface of a bucking board. The outer ball layer may be similarly represented by the lower surface of a muller. If the bucking board, the material to be ground, and the muller all proceed in the same direction at the same speed, no grinding will result. This is the general situation in the mills of today. If, however, the muller is pulled with respect to the board, moving or stationary, grinding will be accomplished effectively. Although grinding in today's mills is primarily the result of cataracting and/or cascading media, the principal place of grinding at high supercritical speeds will be the attrition zone.[1]

In the mineral dressing laboratory of the State Institute for Technical Research, Helsinki, Finland, large quantities of different ores have been ground in a pilot plant ball mill (3x3 ft) at a top speed about 230 pct of the critical. With the same mill, theoretical investigations concerning the grinding characteristics of ball mills equipped with a smooth lining have been carried out up to the speed of 313 pct[7] of the critical. With a smaller mill, the grinding characteristics with a variety of grinding media have been investigated at speeds up to 2000 pct of the

R. T. HUKKI, Member AIME, is Professor of Mineral Dressing, Finland Institute of Technology, Helsinki, Finland.

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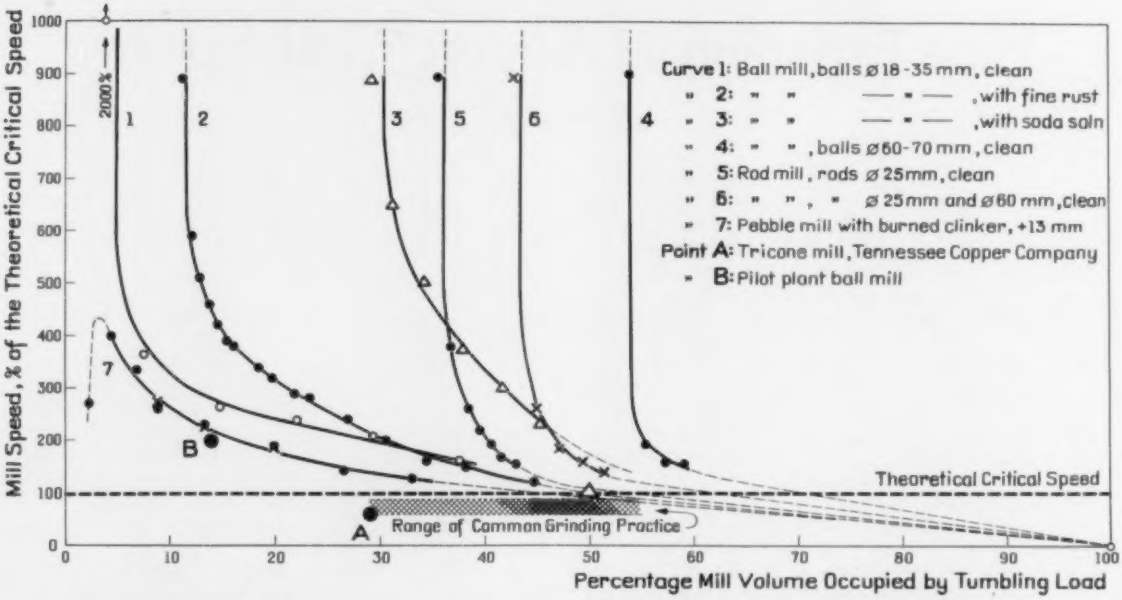

Fig. 1—Mill characteristics at supercritical speeds. Tests were made without feed in a smooth laboratory mill equipped with a variable speed drive. Actual speed of the mill at 2000 pct of the critical was 1550 rpm.

theoretical critical. The results of a series of such experiments are shown in Fig. 1. The points plotted represent experimental boundary conditions at speeds at which the medium was not caught by the mill within 1 min so as to make the medium centrifuge. Thus grinding should be at least theoretically possible at any point over an area between the axes and the respective curve obtained. All tests shown were made without any feed in the mill.

Relationship between Mill Capacity and Specific Gravity of the Medium: In general it may be stated that the grinding capacity of the tumbling medium increases directly as the specific gravity of the medium corrected by the buoyant effect of the pulp or of the bed of solids surrounding the medium.[7] To decrease the buoyant effect to the minimum and thereby increase the effective mass of the medium to its maximum, the mill should be a low-discharge grate mill or a peripheral discharge mill. Fig. 2 illustrates not only the great effect the specific gravity of the medium has on mill capacity, but also the basic influence of the buoyant effect. Fig. 2 has been constructed as follows:

In three similar high-discharge ball mills, all operated at 70 pct of critical speed, ore of 3.0 sp gr is being ground in such a way that one of the mills is loaded with crushed ore pebbles of the same specific gravity, one with steel balls, and one with tungsten carbide balls. The pulp discharged from the mill is supposed to carry 60 pct of solids and the pulp remaining in the mills an average 70 pct of solids, representing a 1.87 sp gr of the pulp. The original specific gravities of the respective media are 3.0, 7.8, and 13.1; the corrected values of effective specific gravities 1.13, 5.93, and 11.23, respectively. If the steel ball mill is given the reference capacity value of 10 tph (point *B*), the tungsten carbide mill should grind about 19.0 tph (point *C*) and the ore pebble mill only 1.9 tph (point *A*).

If the original mills were now to be replaced by three grate mills of the same effective size as the overflow mills, the pulp baths would be largely eliminated. As an extreme situation, it might be assumed that the pulp remaining in the mill is so small in volume that its buoyant effect becomes negligible. Without a great error, the maximum capacities of the three mills will thus be increased to figures directly proportional to the specific gravity values of the media—3.0, 7.8, and 13.1, whereby the tonnages will become 5.06, 13.2, and 22.1 tph, respectively.

From what has been said, it should be clear that to obtain any reasonable capacity in autogenous grinding with crushed ore pebbles of low specific gravity, the mill must be a low-discharge mill. The higher the specific gravity of the medium, the less the percentage difference in capacities of a grate mill vs overflow mill, although the differences in ground tonnages remain constant under the conditions explained.

If the specific gravity of the crushed ore pebbles to be used as a grinding medium can be increased by proper preconcentration such as magnetic separation, sink-float, or other methods, such practice should be encouraged. Also, it should be clear that addition of any medium of higher specific gravity to a charge of lower specific gravity will always increase capacity.

Relationship between Mill Speed and Capacity: In general, it is believed that capacity of a tumbling mill is directly proportional to mill speed, other things remaining constant.[8] In the Sullivan concentrator, the data provided by Banks[9] indicate that the capacity of the large rod mill has increased as a power function of the speed,[10] the exponent being about 1.5. The speed range covered by tests was 50 to 85 pct of critical.

At Outokumpu, Finland,[11] large-scale grinding experiments have been carried out in 9x12-ft autogenous overflow mills equipped with relatively smooth lining, within a speed range of 57.6 to 104 pct of critical. It has been established that the capacity of such a mill, expressed in new tons of —0.2-mm material produced, increases as a power function of the speed, the exponent being 1.4. At present this is probably the only example that can be found

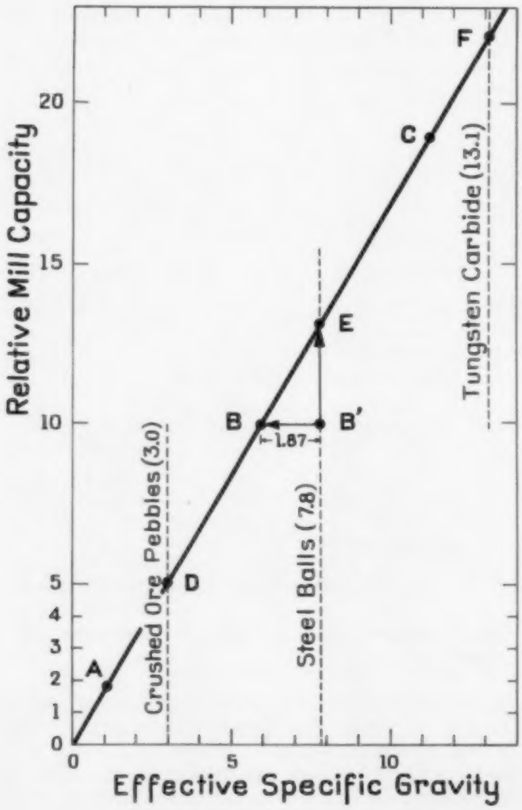

Fig. 2—Relationship between mill capacity and effective specific gravity of grinding media.

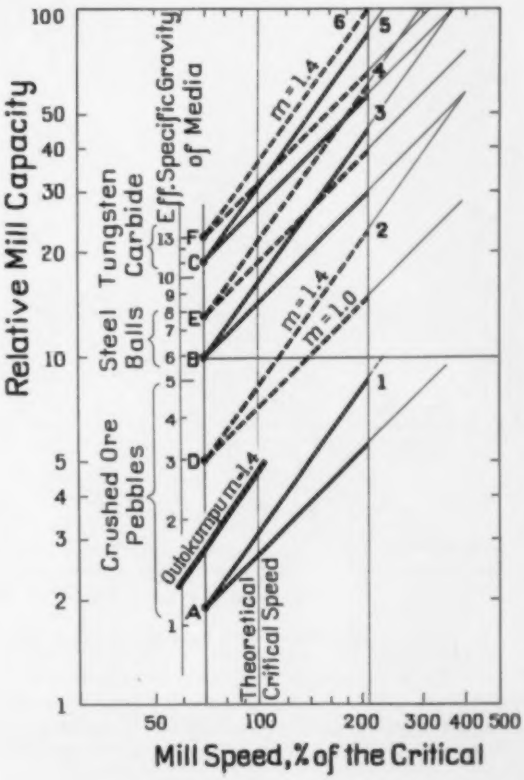

Fig. 3—Relationship between mill capacity and speed shown on logarithmic paper for different grinding media in overflow and grate mills.

anywhere of dependable mill data including the wide subcritical speed range and extending into the low supercritical range. The speed of Outokumpu mills cannot be further increased without a major alteration of the entire circuit, because of the limiting factor imposed by the mill scoop, the tip of which is already rotating at 129 pct of the theoretical critical at a mill speed of 104 pct.

On logarithmic paper, with mill speed on the abscissa and mill capacity on the ordinate, results obtained at Outokumpu give a straight line with a slope of $m = 1.4$ (see Fig. 3).

So far there is only limited experimental evidence for the speed range between 100 and 200 pct of critical, but interesting phenomena can already be predicted to take place in a mill speeded through that range. As an example, the overflow mills and the grate mills described earlier—grinding with crushed ore pebbles, steel balls, and tungsten carbide balls—will be analyzed again.

As shown in Fig. 3, basic capacities of the three overflow mills at a speed 70 pct of critical were found to be 1.9, 10, and 19 tph, respectively, corresponding to points *A*, *B*, and *C* in Figs. 2 and 3. The respective grate mill capacities of 5.06, 13.2, and 22.1 are shown by points *D*, *E*, and *F* in Figs. 2 and 3.

Through each point, two straight lines are drawn in Fig. 3, one at a slope of 1.0, the other at a slope of 1.4. The former line on the logarithmic paper represents the capacity-speed function as generally accepted, the latter the same function based on the evidence obtained at Outokumpu. The following question is now inescapable:

What would be the capacities of these mills if they were speeded, for example, from 70 pct to 210 pct of critical, representing a threefold increase in the speed?

As indicated by Fig. 3, capacity of the grate-discharge tungsten carbide mill should reach 65 to 100 tph at 210 pct. One such super-mill would thus replace 6 to 10 ordinary overflow mills of the same size grinding with steel balls at a speed of 70 pct. Even if the tungsten carbide mill were of the overflow type, its capacity should be 5.5 to 8.5 times that of the reference mill (case *B*). Naturally, the capacity of the reference mill would increase at 210 pct to a figure 3 to 4.6 times that at 70 pct.

Regarding the pebble mills, interesting features are apparent. As seen from Fig. 3, any ordinary overflow ball mill—after being changed to a grate mill and speeded from 70 pct up to 115 to 140 pct—should be able to grind the same tonnage with ore pebbles of 3.0 sp gr as the reference mill with steel balls. However, the starting capacity of a high-discharge overflow mill grinding with ore pebbles (point *A*) would be so low that it might or might not be possible to reach the original reference capacity of 10 tph.

Autogenous grinding may also be performed, of course, with a reasonable success in an overflow type of mill as done at Outokumpu, but obviously at a reduced capacity.

It should be emphasized that the speed range considered above includes only the low supercritical range up to 210 pct. The author has found in pilot plant experiments that such speeds, although

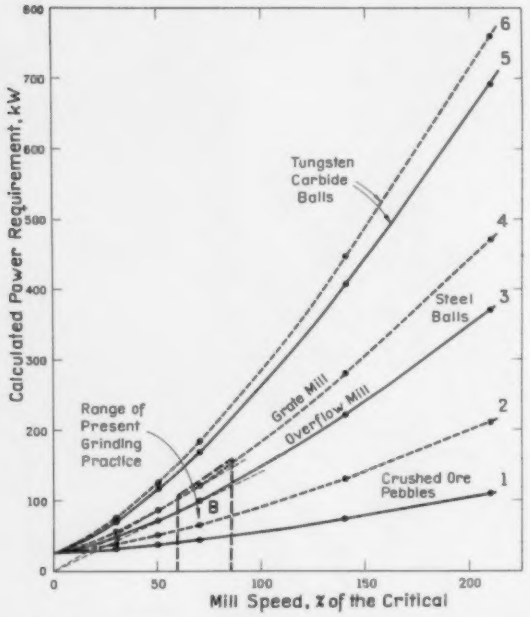

Fig. 4—Relationship between mill capacity and speed on arithmetic paper.

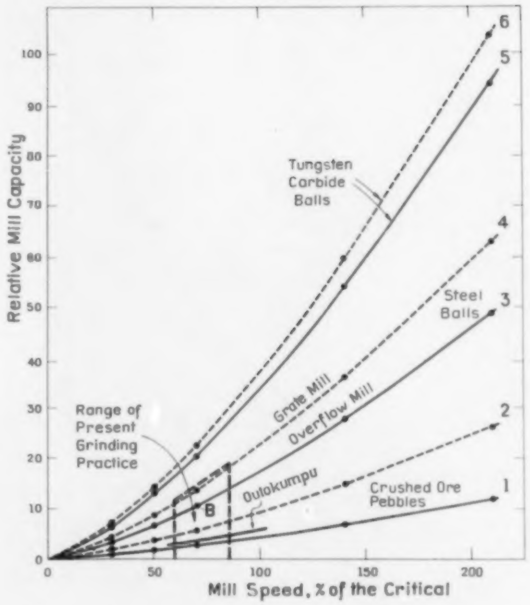

Fig. 5—Relationship between total power consumption and speed.

frightening when compared with the present gentle speeds, are by no means prohibitive. Even at these speeds, the predicted capacity figures seem phenomenal.

In cases where full capacity is not obtained from a mill by its present method of operation, relatively speaking, top capacities under optimum grinding conditions would be still higher than those indicated above.

As the logarithmic method of plotting may not give a clear enough picture of the effect of increasing mill speed on capacity, Fig. 4 is included to show on an arithmetic paper the same data as Fig. 3. Fig. 4 shows also the remarkably small area covered by the present grinding practice, an area illustrating at the same time the extent of the knowledge up to the present time in the field of the science of grinding.

From Fig. 3 it is also apparent that the overflow type of mill equipped with tungsten carbide balls should grind the same tonnage at a speed of about 80 pct of the critical as a grate mill of the same size at a speed of 70 pct. The respective figures for the two types of steel ball mills seem to be 85 to 93 pct vs 70 pct; and for the two types of pebble mills 140 to 190 pct vs 70 pct. In the case of the tungsten carbide medium, the benefit obtained with the grate-type mill construction should thus be very easily compensated by only a slight increase in speed. Even in the case of ordinary steel ball grinding, the moderate increase of speed might turn out to be more economical than the extra expense and care required by the grates. However, the less the specific gravity of the pebbles, the more pronounced will be the favorable effect of low discharge operation on grinding capacity.

The preceding discussion indicates that with increasing speed the capacity of a fine grinding mill might be increased to startling figures. A mill operated under a specified set of conditions must finally reach its grinding limit. No knowledge of this limit exists at present. A slight excess over the maximum digesting capacity of the mill will stop grinding within a very short time by flooding the mill. As all but very few of the fine grinding mills of the world are run at subcritical speeds, and even those very few have barely passed the 100 pct mark, it should be obvious that only a fraction of the total grinding capacity of the large number of mills is in effective use today. Fine grinding at subcritical speeds is analogous to operation at substandard capacity.

Energy Consumption and Importance of Idling Power: In the pilot plant ball mill the idling power (the power required to rotate an empty mill) has been found to be about 30 pct of the power value required to run the mill charged with 50 pct steel ball load at a speed of 70 pct of the critical. When the mill was speeded up to 210 pct, the idling power figure in kilowatts was found to be about 1.6 times as high as at 70 pct. The following numerical example will illustrate qualitatively the important role played by the idling power in the energy consumption in grinding.

Three similar overflow mills all use 30 kw for idling at a speed 70 pct of critical. One of the mills after being charged with iron balls draws a total of 100 kw. The difference between the two figures shows the power required to tumble the ball load. In the second mill the ball load is replaced by a crushed ore pebble load of 3.0 sp gr. The specific gravity of the pulp within the mills is assumed to be 1.87, the same as in the example described earlier. As a first approximation, the power required to tumble the pebble load would decrease in the ratio of the effective specific gravities of the two media (1.13:5.93) or to 13.3 kw. Similarly, the power required to tumble a load of tungsten carbide balls occupying the same volume in the third mill would increase in the ratio of 11.23:5.93 or to 133 kw.

As a first approximation, the grinding capacities of the three mills are assumed to be directly proportional to the effective specific gravities of the three media. Thus if the capacity of the mill equipped with steel balls is taken as 10 tph, the pebble mill will grind 1.9 tph and the tungsten car-

bide mill 19.0 tph as was shown earlier. The general situation may now be summarized as follows:

Factor	Pebble Mill	Ball Mill	Tungsten Carbide Mill
Idling power	30 kw	30 kw	30 kw
Tumbling power	13.3 kw	70 kw	133 kw
Total power	43.3 kw	100 kw	163 kw
Capacity	1.9 tph	10 tph	19.0 tph
Energy used	22.7 kw-hr per ton	10 kw-hr per ton	8.6 kw-hr per ton

This example leads to the following statement:

In a mill operated at constant speed, the energy consumption expressed in kilowatt hours per ton should decrease with increasing specific gravity of the medium, or more broadly, with increasing mass of the medium.

If the mills are now speeded up to 210 pct of critical, it should not be unreasonable to expect that, as a first approximation, the *tumbling* powers and the tonnages may increase to figures 4.6 times ($3^{1.4}$) as high as those given above, respectively. The idling power, however, will increase only 1.6 times. The total power drawn calculated for the various cases is shown in Fig. 5. The energy values are now as follows:

Factor	Pebble Mill	Ball Mill	Tungsten Carbide Mill
Idling power	48 kw	48 kw	48 kw
Tumbling power	61 kw	322 kw	610 kw
Total power	109 kw	370 kw	658 kw
Capacity	8.7 tph	46 tph	87 tph
Energy used	12.5 kw-hr per ton	8.1 kw-hr per ton	7.55 kw-hr per ton

Qualitatively, the following statement should be justified:

With increasing speed, the share of idling power in the final energy consumption figure decreases. As a result, final energy consumption should also decrease.

In the two sets of figures, the idling power does not include a possible correction originating from the fact that the weight of the tumbling load is different from mill to mill. Naturally, the increasing weight of the medium tends to reduce the difference in results obtained in the above calculations. For a comparison it might be mentioned that a figure of 23 pct for the idling power at a speed of 80 pct of critical has been reported by Gow and Guggenheim[12] for a 6 x 4-ft mill when the normal ball load was packed around the axis.

Fig. 6 is based on numerical data obtained by the technique outlined above. It includes also the results of the two sets of examples just presented. At near zero speeds the idling power drawn by the motor divided by the infinitesimal capacity figures leads to very high energy values, which, of course, have no practical significance.

If the idling power could be reduced to zero, the ideal energy-speed relationship would be represented by a horizontal line. The resulting energy value would depend primarily on characteristics of the ore and objectives of the operation but would be independent of the type of the mill (overflow or grate mill), specific gravity of the medium, and mill speed.

The examples as given should be qualitatively sound. The high idling power consumption shown in the case considered, however, may represent rather bad operating conditions. In the pilot plant

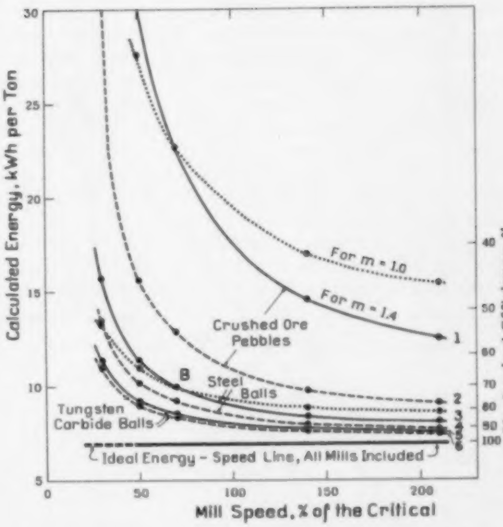

Fig. 6—Relationship between energy consumption and speed for different types of mills, based on the pilot plant ball mill data.

mill the substantial power loss can be largely credited to the speed regulator. A well designed modern mill can perform at very much better mechanical efficiency. As a result, the differences between the separate curves in Fig. 6 will be reduced. The higher the mechanical efficiency, the more the curves approach each other and finally a constant value. It might be mentioned here that the energy consumption at Outokumpu[11] remained very sharply at a constant value in autogenous grinding between speed limits of 57.6 and 104 pct. Both power consumption and capacity went up as a power function of the speed with an exponent 1.4.

Bond[8] has made a statement that, according to the general opinion, the mechanical efficiency of large-diameter mills is greater than that of small-diameter mills. In other words, the kilowatt-hour per ton figure decreases with increasing mill size. To find an explanation for this, the author has plotted on a logarithmic paper capacities of rod and overflow ball mills of different sizes against the mill weights as indicated in a catalog published by Allis-Chalmers.[13] As shown by Fig. 7, rod mill capacity seems to be a power function of mill weight, the exponent being 1.30; for the ball mill it has the value of 1.43. In the case of the smallest rod mill included, 5520 lb of mill weight are needed for each hourly ton of capacity, whereas only 2016 lb are required per ton of capacity with the largest rod mill. The respective figures for the ball mills are 15,000 and 3600 lb per ton.

As a first approximation it may be assumed that the idling power of a mill is a linear function of the weight of the mill at the same percentage value of the critical speed. Accordingly, the percentage of power available for actual grinding of the total power drawn by the motor should increase with increasing mill size.

The idling powers drawn by grinding units operating in industry have seldom been evaluated. As mechanical efficiency of mills must be based on idling power consumption, it should be of primary interest to every operator to know this basic factor as well as possible. It should also be the responsi-

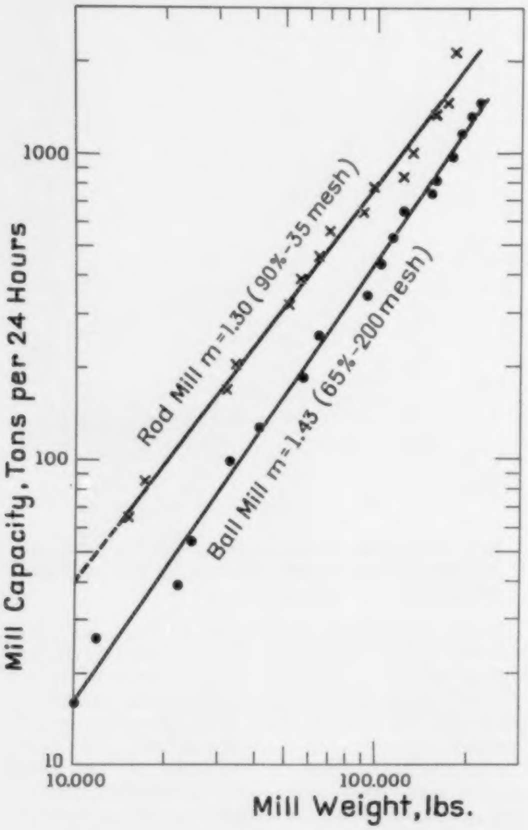

Fig. 7—Relationship between mill capacity and mill weight presented on logarithmic paper.

bility of grinding mill manufacturers to supply their customers dependable data concerning it.

Power Input With and Without Feed: Bond[14] has reported that the power input to a wet grinding ball mill is practically the same with and without feed to the mill. Accurate measurements, according to Bond, have shown that slightly more power is drawn without feed, a fact he explains as resulting from a certain lubricating action by the pulp in the mill. Bond's observations are basically correct. However, the speed range within which they apply is the normal narrow speed range of subcritical grinding. It has been explained by the author of this article that the smaller power input with feed is primarily the result of the buoyant effect of the pulp in an ordinary high discharge mill operated at low speed.[7] The effective mass of the charge is thereby lowered. With increasing speed, the medium will be more and more pulled out of the pulp body. Tests made in the pilot plant *rod mill* (3 x 4 ft) have shown that the crossing point of the two lines (one indicating the power-speed function with feed, the other the same function without feed) was located at about 60 pct of the critical in one series of grinding experiments.[7] Beyond that more power was drawn with feed than without. The difference in total power input increased linearly from the crossing point up to 135 pct of critical, the top speed at which the mill could be operated because of its shallow wave liners. At 135 pct the power input with feed was already 27 pct higher than the respective figure without feed. At present, the author has no dependable figures to show this same difference for ball mills operating at supercritical speeds. All indications are that the difference between the two power values will continue to grow (linearly or as a power function) with speed.

Relationship between Tumbling Charge and Speed: The tests shown in Fig. 1, although run in a laboratory-size mill, should qualitatively at least indicate the relationship between the tumbling charge and the speed for grate or peripheral discharge mills. The most important case to consider here is the fact that the threshold speeds for different loads of pebbles was found to be less than the respective speed values for a steel ball mill. This is shown by curves 2 and 4, respectively, in Fig. 8.

As it has not been possible for the author to run actual experiments to demonstrate to what extent the situation might change if the mill were an overflow type with a pulp bath, the corresponding cases were roughly evaluated by assuming that the friction between mill lining and tumbling charge varies directly as the effective mass of the medium and that the mill speed could be increased at the same rate the friction decreases from the basic values given by curves 2 and 4. Thus the steel ball curve 4 would be represented by curve 3 in the case of an overflow-type mill with pulp of 1.87 sp gr. Similarly, curve 2 would be represented by curve 1.

To test the correctness of the procedure, the 3x3-ft pilot plant ball mill was charged with 48 pct load of limestone pebbles and run in a closed circuit with a mechanical classifier. Limestone was fed to the circuit at about 1 tph through an open circuit 3x4-ft rod mill. At first, the maximum speed that could be used in the pebble mill was about 180 pct of critical. After the pebbles had become somewhat worn, the mill operated smoothly at a speed of 230 pct. This is shown by point *P* in Fig. 8. As indicated, the point agrees well with the calculated threshold curve despite the fact that the problem setting is not comparable in every respect. As very little is known so far about the behavior of different media in various types of mills operated at supercritical speeds, interesting and surprising phenomena are bound to be discovered in further studies.

Autogenous vs Steel Ball Grinding: Like the case history of grinding at supercritical speed, autogenous grinding also dates back many decades. One early reference from 1908 has been given by Hardinge.[18] Considerable work on the subject seems to have been done especially in South Africa as well as in the U.S. A well known modern application of auto-

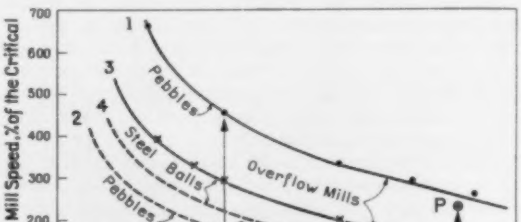

Fig. 8—Relationship between maximum mill speed and percent tumbling load for overflow and grate mills operating with balls and pebbles.

genous fine grinding within the subcritical speed range has been investigated and described by Crocker.[18]

In order to test experimentally whether or not it would be possible to replace steel balls in an ordinary overflow-type ball mill with crushed ore pebbles and to recover the loss of capacity by speeding the mill, the tests shown in Table I were carried out. In these tests limestone was ground in the pilot plant ball mill operating in closed circuit with a mechanical classifier as explained above. The mill had smooth liners. In test 1 it was run at the usual speed of 70 pct of the critical with a 24 pct load of steel balls. Under these circumstances the mill should have included all the refined features of the well known Copper Hill tricone mill grinding of the Tennessee Copper Co. In other words, the example selected for a comparison should represent a very efficient grinding circuit according to the present standards.

At first it was expected that after the balls had been replaced with limestone pebbles, a power draft comparable to that in test 1 could be used as a guide for subsequent tests. This resulted in complete failure. Only after the curves of Fig. 5 had been established could it be realized that equal energy consumption in overflow-type mills between the two types of tests is absolutely impossible. After that more pebbles were added to the mill and the mill was speeded finally up to its top speed of 230 pct. Test 2 shows a case of a smooth, steady state operation run for several hours.

The following data may be used to compare the results of test 1 and 2:

Specific gravity of limestone = 2.8
Assumed pulp density in the mill = 65 pct solids
Specific gravity of the pulp = 1.72
Effective specific gravity of steel balls = 6.08
Effective specific gravity of limestone pebbles = 1.08
Reference capacity of the steel ball mill at 70 pct speed = 1 tph
Calculated capacity of the pebble mill at 70 pct = 0.178 tph
Calculated capacity of the pebble mill at 230 pct = 0.94 tph
(based on exponent $m = 1.4$)

According to the analysis shown above, the expected capacity of the high-speed limestone pebble mill should be 94 pct of that of the low-speed ball mill.

In Table I the new tons of −x mesh material produced in the fine grinding circuit have been evaluated. It will be found that the capacity of the pebble mill when compared with the respective figures for the ball mill will be about:

92 pct for −48 mesh material ($m = 1.38$)
91.8 pct for −65 mesh material ($m = 1.38$)
83.5 pct for −100 mesh material ($m = 1.30$)
81.2 pct for −150 mesh material ($m = 1.27$)
80.5 pct for −200 mesh material ($m = 1.26$)

As the Outokumpu exponent $m = 1.4$ is based on −0.2-mm material (65 mesh), the example given here checks well with the evidence obtained at Outokumpu. Had the true exponent been the value of $m = 1.0$ as accepted today, the result obtained in test 2 would have been absolutely impossible.

Although no great accuracy can be claimed for the samples and for the figures of the screen analyses of the tests described, they do give the first real evidence that it is possible to install high-speed autogenous mills to compete in capacity and in performance with low-speed steel ball mills. The limestone pebble mill in the example given has actually presented almost the worst possibility in practice regarding the specific gravity, and at the same time the wrong type of mill (overflow mill).

In an earlier test the idling power to run the ball mill motor and speed regulator without operating the mill itself was found to be 2.7 kw at 70 pct speed and 3.9 kw at 230 pct. The respective idling power figures with the mill weighing about 800 kg were measured as 3.1 and 5.3 kw. No idling power figures are available for the loaded mills. If the weight of the charge (medium plus pulp) is given a round figure of 1000 kg in both cases, and the increase in idling power for the increased weight grows at about the same rate as in the two cases explained above, the idling power figures for the two tests may be assumed to be 3.6 and 7.05 kw.

Table I. Steel Ball Vs Autogenous Grinding

	Test 1		Test 2	
	Rods	Steel Balls	Rods	Limestone Pebbles
Load, pct		24		48
Mill speed, pct		70		230
Circulating load, pct		180		225
Power, kw		6.5		9.7
Capacity, kg per hr		955		955
Product	**Feed**	**Classifier Overflow**	**Feed**	**Classifier Overflow**
−35 mesh	77.5	100.0	79.4	99.9
−48 mesh	64.8	99.6	67.6	99.6
−65 mesh	53.3	97.4	55.7	96.2
−100 mesh	45.5	91.3	46.6	84.6
−150 mesh	34.3	73.2	36.2	67.8
−200 mesh	27.7	58.8	29.1	54.1
New Kg per Hr of				
−48 mesh material		332		305
−65 mesh material		421		387
−100 mesh material		437		365
−150 mesh material		372		302
−200 mesh material		297		239

In test 1 the total power drawn was 6.5 kw. The share of the tumbling power is 2.9 kw. If the tumbling powers developed are in direct ratio to the effective specific gravities of the media, the tumbling power for the limestone pebble mill run at 70 pct would be 0.515 kw, and at 230 pct 2.73 kw. As the idling power for the pebble mill was estimated to be 7.05 kw at 230 pct, the total power should be about 9.78 kw. As seen from Table I, it was actually found to be 9.7 kw.

Although the result of this analysis may look to be a tailor-made figure, it was found in the first trial. It should give some confidence in the method of reasoning outlined here.

If the energy consumption figures in test 1 and 2 are studied on the basis of curves drawn in Fig. 5, showing the mill characteristics under different circumstances for this same pilot plant ball mill, the agreement is excellent.

Basic Equations of Fine Grinding: The grinding capacity of a unit-size mill 1 ft ID and 1 ft long may be written as follows:

$$T = c_1(\delta - \delta') \text{ tph} \qquad [1]$$

where δ = specific gravity of the grinding medium
δ' = average specific gravity of the pulp or of bed of solids within the mill
c_1 = a constant related with the characteristics of the ore, fineness of grinding, etc.

As shown by Fig. 3, the capacity of a mill is a

function of the percentage critical speed (n_p) raised to power m.
Thus:

$$T = c_2(\delta - \delta')\, n_p^{\,m} \text{ tph} \qquad [2]$$

Indicating that

$$n_c = 76.63 \frac{1}{\sqrt{D}} \text{ rpm} \qquad [3]$$

$$n_p = \frac{n}{n_c} 100 \text{ pct} \qquad [4]$$

$$n_p = \frac{n\sqrt{D}}{0.7663} \text{ pct} \qquad [5]$$

where n = actual mill speed, rpm
n_c = calculated critical speed, rpm
n_p = calculated percentage critical speed
D = inside diameter of the mill, in feet.

Eq. 2 may be rewritten as follows:

$$T = c_3(\delta - \delta')\, n^m (\sqrt{D})^m \text{ tph} \qquad [6]$$

Eq. 6 was derived for a unit-size mill 1 ft ID. In a mill D ft ID the mass of a similar tumbling charge occupying the same percentage volume as before is a function of D^2. Accordingly, capacity of the mill should be written as

$$T = c_4(\delta - \delta')\, n^m (\sqrt{D})^m D^2 \text{ tph} \qquad [7]$$

It is generally accepted that capacity of a mill is directly proportional to its length. If length is L ft, capacity becomes

$$T = c_4(\delta - \delta')\, n^m D^{(2+m/2)} L \text{ tph} \qquad [8]$$

Eq. 8 is the basic equation of mill capacity in a general form. If $m = 1.4$ as at Outokumpu, capacity is expressed as

$$T = c_4(\delta - \delta')\, n^{1.4} D^{2.7} L \text{ tph} \qquad [9]$$

As a first approximation, power consumption in grinding may be assumed to equal the sum of the idling power and the tumbling power. The idling power required should increase with increasing mill weight (size) and with increasing speed. At near zero speed it always has a definite base value. If this value for the unit mill is equal to P_o, its value for a mill of a different weight would be $k\ P_o\ (W/W_o)$, where k is a constant, W weight of the mill, and W_o weight of the unit mill. Factor k shows the relationship between the idling power and mill weight at a constant speed. It is not known whether this relationship is linear or exponential.

For relatively low speeds (up to 200 pct of critical) the idling power may be assumed to increase linearly with increasing speed. At a speed n, the idling power may be written as

$$P_i = k\, P_o\, (W/W_o) + q\, n \text{ kw} \qquad [10]$$

where q is a constant.

The tumbling power should be proportional to the force created in the mill. As the grinding capacity of the mill is also proportional to this same force, an expression which follows the law of Rittinger, the tumbling power may be written as

$$P_t = c_5(\delta - \delta')\, n^m D^{(2+m/2)} L \text{ kw} \qquad [11]$$

The total power drawn by the motor will be

$$P = P_i + P_t \text{ kw} \qquad [12]$$

The energy used in grinding a unit weight (a ton) of ore is obtained by dividing Eq. 12 by Eq. 8:

$$E = \frac{k\, P_o(W/W_o) + q\, n}{c_4(\delta - \delta')\, n^m D^{(2+m/2)} L} + \text{constant kw-hr per ton} \qquad [13]$$

which is the final general expression for energy consumption. From Eq. 13 it is apparent that the energy consumption in grinding expressed in kilowatt-hours per ton should decrease with:

1) Decreasing idling power of the mill.
2) Increasing specific gravity of the grinding medium.
3) Decreasing buoyant effect of the pulp or of bed of solids.
4) Increasing speed of the mill.
5) Increasing diameter of the mill (raised to power $2 + m/2$).
6) Increasing length of the mill.
7) Decreasing relative weight of the mill itself.

It should be emphasized that the variable part in Eq. 13 may amount in a modern mill to 5 to 15 pct of the total power consumption for normal speed grinding operations with steel media. In a poorly designed mill its share might go up to 30 pct or more.

Shape of Grinding Media in Mills Operated at Supercritical Speeds: It is not coincidence, but the result of a long experience, that the working surface of the muller referred to earlier has been made cylindrical. It is not coincidence that the seasoned crushed ore pebbles in the large Outokumpu mills operated at low supercritical speeds are elliptically shaped. While the shape of a rod is basically better than that of a ball in supercritical fine grinding, the best overall surface for the medium might be obtained by introducing into the mill media that already have the shape resembling the average in a seasoned charge.

Should extremely high speeds become desirable, a rod mill in general may be run at a higher speed than a ball mill under otherwise parallel conditions.[7] It has been stated before that mill speed increases with increasing mass of the individual grinding piece. Of any useful shape of the media, a rod always has the highest mass.

Wear: It has been the author's experience that in all discussion of supercritical grinding, criticism has been focused on the question of wear.

In the present method of fine grinding, the heaviest cost item is usually the grinding medium, the steel balls. In many, if not in all grinding plants, it would be most desirable to replace the expensive steel with the inexpensive ore pebbles. The unavoidable reduction in capacity can be partially, fully, or more than fully recovered by increasing mill speed, as was shown earlier. The resulting moderate or even heavy medium wear might turn out to be an economical success rather than a source of concern as the worn out material reports in a final product.

Thus in the case of autogenous grinding the question of wear can be reduced to include the liners only. The following cases should be taken into consideration:

1) In some grinding operations the abrasive qualities of the material to be ground are so light as to be of no concern even at substantial supercritical speeds. Smooth liners of Ni-hard, for example, would give good service. This is the situation with many dry grinding operations.

2) In cases where liner wear may be a delicate problem, a compromise should be made between expense of liners, speed, and type of mill (grate vs

overflow). Grate-type mills will always favor capacity at a more moderate speed.

3) There may be a number of fine grinding problems that can be handled more economically at subcritical speeds with the present standard procedure rather than at supercritical speeds.

4) At supercritical speeds, autogenous lining of the mill by pieces of tumbling medium becomes a possibility as soon as the mill is provided with proper breaking bars that will prevent the sliding of one or several outermost layers of medium. Attrition grinding will naturally now take place in the zone between the fixed layer and the movable layer of medium opposite.[7]

The whole question of mill liners should be turned over to the metallurgists for a new basic study. Substantial improvements will no doubt be possible. Ni-hard and tungsten carbide should form a good reference pair of materials either in use at present or at least within the possibilities of being used. Once the metallurgists can produce an alloy of 10 to 100 times better wearing characteristics than the best at present, the whole unit operation of grinding will face a revolution.

At present autogenous supercritical grinding appears to face the most promising future. In plants where steel consumption is high or plants far from steel centers, the combination of inexpensive local grinding medium and sufficient mill speed should turn out a highly successful economical undertaking. The experience obtained at Outokumpu in industrial scale offers proof beyond all doubt.

It often happens that the grinding section is the bottleneck of the entire operation of a mine plant. From what has been said it should be obvious that the capacity of almost every fine grinding mill may be increased by increasing the speed. Even if direct grinding costs per unit of ore treated should go up, it might be economically sound to go to higher speeds. The economics of a mining operation should not be based on figures indicating ball wear or liner wear or any other single item of costs, but on the overall result of the whole undertaking from mine to finished product. With increasing scale of operations unit costs usually go down.

New Grinding Circuit: The wet fine grinding circuit of today consists essentially of a grinding unit and a mechanical classification unit placed side by side and operated in a closed system. The shape of the classifier is determined to some extent by the transportation problem involved.

In a few new installations mechanical classifiers have been replaced by cyclones. The pulp motion is affected by a pump and the sands (cyclone underflows) are returned by gravity.

If fine grinding is to be accomplished in mills operated at supercritical speeds certain major changes in circuit structure will be necessary—1) elimination of the mill scoop, 2) feeding medium, ore and sands by gravity, 3) placing the mechanical classifier on a higher level, and 4) pumping the mill discharge to classifier.

As soon as this principle is accepted, the shape of the classifier becomes of minor importance. As a matter of opinion, supercritical grinding should turn out to be a major incentive for new developments in the field of classification.

Investigations carried out in South Africa[17] have shown that it takes more power to operate a mill scoop in a closed grinding circuit than to pump the mill discharge into a classifier placed above the mill and return the sands by gravity. If this is correct in a general case, there is every reason to abandon present concepts regarding the architecture of fine grinding circuits.

Conclusions

The possibility of grinding at supercritical speeds has been known for more than 50 years. Time after time it has been rediscovered in a number of countries. It seems, however, that none of the investigators really grasped the simplicity of the basic principles involved. Even laboratory experiments have always been discontinued without convincing success.

In the present technical world grinding is one of the few fields of engineering where low-speed operation has been universally accepted. Today, however, grinding at supercritical speeds is already an established fact and an economic success on an industrial scale.

A number of the basic ideas of grinding at supercritical speeds, partly or fully described in this article, have been covered by patents pending.

References

[1] H. A. White: Theory of Tube-Mill Action. *Journal of the Chemical, Metallurgical, and Mining Society of South Africa*, 1905, vol. 5, p. 290. Summarized by R. H. Richards: *Ore Dressing*, vol. 3, pp. 1336-1340, McGraw-Hill, New York, 1909.

[2] A. W. Fahrenwald and H. E. Lee: *Ball Mill Studies. AIME TP 375*, 1931, pp. 3-53.

[3] A. W. Fahrenwald: Some Fine-Grinding Fundamentals. *AIME Trans.*, 1934, vol. 112, pp. 88-115.

[4] W. A. Perow and W. J. Brand: Feinmahlen der Erze. *Verlag Technik*, Berlin, 1954, p. 86.

[5] W. Anselm: *Die Zementherstellung*. Berlin, 1941.

[6] H. E. Rose and R. M. E. Sullivan: *Ball, Tube and Rod Mills*, p. 42. Constable, London, 1958.

[7] R. T. Hukki: Grinding at Supercritical Speeds in Rod and Ball Mills. International Mineral Dressing Congress, pp. 1-25. Stockholm, 1957.

[8] F. C. Bond: Mathematics of Crushing and Grinding. In *Recent Developments in Mineral Dressing*, pp. 101-115. Institution of Mining and Metallurgy, London, 1953.

[9] H. R. Banks: The Rod Mill in the Sullivan Flow. *Trans.*, Canadian Institute of Mining and Metallurgy, 1952, vol. 55, pp. 255-261.

[10] R. T. Hukki: Tumbling Mill Capacity and Power Consumption as Related to Mill Speed. *AIME Trans.*, 1954, vol. 199, pp. 728-730.

[11] H. Tanner and T. Heikkinen: Crushing and Grinding at Outokumpu. International Mineral Dressing Congress, pp. 1-14, Stockholm, 1957.

[12] A. M. Gow and M. Guggenheim: Dead-Load Ball-Mill Power Consumption. *Engineering and Mining Journal*, 1932, vol. 133, p. 652.

[13] Allis-Chalmers: *Grinding Mills*. (Catalog, 1951.)

[14] Forum on Ball Milling. *Canadian Mining and Metallurgical Bulletin*, August 1957, vol. 50, p. 515.

[15] H. Hardinge: Making Rock Grind Itself. *Engineering and Mining Journal*, June 1955, pp. 84-90.

[16] B. S. Crocker: Screened Ore Used for Fine Grinding at Lake Shore Mines. *AIME Trans.*, 1952, vol. 193, pp. 499-508.

[17] W. B. Stephenson: Private communication.

Discussion

Fred C. Bond *(Consulting Engineer, Allis-Chalmers Mfg. Co.)*—This article is interesting because it deals with the fundamentals of grinding in a novel manner. However, it is somewhat reminiscent of Mark Twain's famous evaluation of science as the production of pounds of conjecture from ounces of fact. Extrapolations abound, and some cases they are treated with a seriousness that is undeserved.

Tests should undoubtedly be made of wet grinding at supercritical speeds, using smooth mill lining and mill charges of large grinding balls as well as pebbles. However, the performance predicted in the article needs more qualification than it has received.

The author starts out by stating that the wet mill capacity varies as the effective specific gravity of the grinding medium in the pulp, with the corollary: 1) that in overflow the medium behaves as if it were completely immersed in the pulp, and 2) that in grate dis-

charge mills its gravity is unaffected by the pulp; however, he implies that its grinding efficiency is unaffected by the absence of pulp.

He continues with the statement that mill capacity varies approximately as the mill speed. This is commonly accepted throughout the usual grinding range, but Hukki extends it to beyond 200 pct of critical speed. Finally, he quotes data from Outokumpu on a wet overflow pebble mill (autogenous grinding) ranging from 58 to 104 pct of critical speed and extends this to beyond 200 pct. The weight of the proper ball charge for this high extrapolated speed receives little or no attention.

Figs. 2, 3, and 4 result directly from these extrapolations. They involve several questionable assumptions, but the most serious seems to be disregard of the decreased amount of grinding media necessary to operate mills at these high speeds without centrifuging. A decrease in amount of grinding media in this range should reduce grinding capacity.

The importance of idling power to energy consumption in kilowatt hours per ton is evidently exaggerated by the high power required to run the pilot mill on tires and rollers. The proportion of the full load power required to rotate a large empty ball mill with properly lubricated trunnion bearings is far less than 30 pct, so that its curves would be much flatter than those shown in Fig. 6.

It is true that the mechanical efficiency of conventional mills increases with mill diameter; a fair exponent of the mill diameter is 0.2. However, Fig. 7 may be misleading because the listed weights of the empty mills are not directly proportional to their internal volumes. This is apparent when the listed weights of the 40 pct ball charges are compared with the listed weights of the empty mills.

Fig. 8 shows the maximum possible percentage medium load at different speeds without pulp in the mill. The behavior with pulp is highly conjectural, particularly with steel grinding balls.

The work index is calculated from the equation

$$Wi = W \Big/ \left(\frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}} \right)$$

The last column gives the corrected work index for the standard mill 8 ft ID, considering that efficiency varies as the inside mill diameter to the power 0.20. Tests on 173 limestone samples in the Allis-Chalmers laboratory gave an average work index of 12.85.

The equivalent work index of 11.3 for a 24 pct charge of steel balls at 70 pct of critical speed compares with 19.1 for a 48 pct charge of limestone pebbles at 230 pct of critical speed. Thus the low-speed mill required only 59 pct of the energy input required per ton in the high-speed mill for the same grind and gives slightly less than the average limestone work index.

The capacity of the slow-speed ball mill with a ball charge of only 24 pct is much less than it would be with a full ball charge, so that the high-speed pebble mill capacity is considerably less than that of conventional ball mill.

The author's "Basic Equations of Fine Grinding" contain no term for the amount of the grinding charge. He states that the capacity of a mill is directly proportional to its length but that according to his equation the kilowatt-hours per ton should decrease with increasing length of the mill.

Hukki largely avoids the crucial question of metal wear in high-speed ball and rod mills. He does not even state whether the wear per ton ground will be higher or lower than in mills of conventional speeds. In this respect he seems to abandon his case for high-speed ball and rod mills and suggests changing to autogenous grinding.

Grinding is accomplished in a conventional tumbling mill by a combination of impacting, rolling, and sliding contacts. The amount of metal wear in sliding or rubbing contacts is greater than that in impacting or rolling. At supercritical speeds with reduced ball or rod charges and a smooth lining, a large proportion of the total work done is accomplished by the medium charge sliding on the mill lining. The liner wear should be increased, and the medium wear in pounds per ton ground is probably increased. The necessary reduction in the amount of medium present reduces the mill capacity and more or less balances the increased capacity resulting from higher speed. Additional tests are necessary to determine which effect will predominate.

A tumbling mill can apparently carry a larger load of pebbles or rock at high speeds than steel balls or rods. Autogenous grinding at high speeds appears to be more promising than grinding with steel media, because of decreased metal wear costs, even though the mill capacity may be decreased. The data in Table I indicate that the power cost will be much higher, but this should be confirmed by additional tests.

R. T. Hukki *(author's reply)*—The author is grateful to F. C. Bond for his discussion because it brings out a number of points that need clarification.

Several remarks raised by Bond seem to be focused on the amount of grinding medium, especially of balls, in the mill. It is apparent that Bond does not accept the results obtained at the Tennessee Copper Co. as a valid basis for the analysis presented, whereas the author does. This seems to be the primary reason for the controversy.

It has been shown at Tennessee Copper Co. that a reduction of the ball load from 45 to 29 pct of the mill volume has increased the fine grinding capacity of the tricone mill.[18] According to a later report,[19] the ball load was further reduced to 20 pct. As the pilot plant ball mill used for investigations reported resembles closely in shape the tricone mill at Tennessee Copper, the fact that a 24 pct steel ball load was used in the test instead of the 48 pct load as in the case of limestone pebbles should have given the balls a very favorable basis for comparison, as was clearly indicated in the article. The author admits that the figures might have been more convincing if a 48 pct ball load actually had been used.

If the Tennessee practice is further accepted as a sound basis of fine grinding with steel balls, the percentage ball load may remain constant over a wide speed range. Accordingly, it has been possible to operate our pilot plant ball mill with the 24 pct ball load indicated at speeds of 50 to 230 pct without any change in the amount of medium. The capacity of the mill under these conditions seems to follow the 1.4 relationship as indicated up to at least 140 pct of the critical. Beyond that, however, the auxiliary equipment available in our laboratory could not handle the large volume of pulp. For example, if one classifier had been used at a speed 70 pct of the critical, 4 to 5 similar classifiers

Data from Table I

Test No.	Media	Speed, Percent of Critical	Load, Percent of Volume	Short Tons per Hr	W Kw-Hr per Ton	Feed 80 Pct—μ	Product 80 Pct—μ	Wi Work Index	Wi Standard Mill
						(F)	(P)		
1	Steel Balls	70	24	1.053	6.18	450	120	14.0	11.3
2	Limestone Pebbles	230	48	1.053	9.21	420	135	24.7	19.1

would have been necessary at 210 pct to obtain equal classification conditions.

The work index according to Bond's basic definition calls for conditions of the *same relative mechanical efficiency*. In the paper the author has clearly shown how the mechanical efficiency of the pilot plant mill varies widely depending on the media used and on the mill speed. It is therefore surprising that Bond himself forgets his own definition of the work index and uses the data reported in Table I to calculate indices with which he intends to show the inefficiency of the high-speed operation. As a result he has demonstrated one of the common errors in the usual method of evaluation of the work index.

The equations presented must naturally be corrected as soon as dependable evidence becomes available. Regarding the effect of mill length on energy consumption, Bond has apparently misunderstood Eq. 13. The mill length appears a minor factor in connection with the variable part of the equation. The tumbling power consumption and the capacity still remain directly proportional to the mill length.

Regarding the wear of media and mill lining it should be clear that with increased speed the wear will increase and will probably increase even in terms of pounds per ton of material ground. Exact figures, whatever they may be, must be obtained in actual field practice.

The author is fully aware of the existence of many unsolved details in this study of grinding at supercritical speeds. The article is not a report of exhaustive experimental investigations—a task of dimensions far beyond our reach. Rather, it is a simplified analysis of some of the most evident variables in grinding, partly supported by experimental evidence, partly not. Of one thing the author is fully confident—independently of the stand or fall of the ideas presented in the exposing light of future critical investigations, the science of grinding will thereafter rest on much more solid foundations than today.

References

[18] Anon: The Remarkable Case of the Copperhill Ball Mill. *Engineering and Mining Journal*, 1953, vol. 154, pp. 86-89.

[19] F. M. Lewis, and J. E. Goodman: Grinding Practice at Tennessee Copper Co.'s Isabella Mill. *AIME Trans.*, 1957, vol. 208, pp. 1253-1255.

Further discussion of this paper sent (2 copies) to AIME before June 30, 1958, will be published in MINING ENGINEERING.

Discussion

Petrologic Methods for Application to Solid Fuels of the Future

by James M. Schopf

(*MINING ENGINEERING*, page 629, June 1956, *AIME Trans.*, vol. 205)

Gilbert H. Cady *(Senior Geologist, Head of Coal Division Emeritus, Illinois State Geological Survey, Urbana)*—Those coal mining and preparation engineers and operators who read this article will probably be most concerned with those parts which deal with the applied aspects of coal petrology in the fields of mining and technology. Actually the two categories overlap to such a degree that they are essentially one.

The article appears to suggest that there are two points of veiw in the field of applied coal petrology. From one viewpoint the interest is in the attributes of the various macerals (Fig. 4)—vitrinite, exinite, and inertinite—in terms of utilization (when the coal is burned, coked, gasified, hydrogenated, etc.). From the other point of view, assuming that the macerals do possess individuality in behavior, interest attaches to the possibility that coal of a particular type (maceral composition) can be prepared by discriminating methods of preparation and blending. Most of the 29 items listed for mining and technology can be assigned to one or the other of these two categories.

Somewhat the same simplicity that resides in the items of the proximate chemical analysis is desirable for the petrologic analysis. This simplicity appears to be fairly well achieved by the group maceral device provided mineral matter is also included. At present, without fully adequate experimental substantiation, the three types of material represented by the group macerals vitrinite, exinite, and inertinite are regarded as sufficiently different in composition and properties so that the preponderance of any one type gives the coal distinctive properties provided it is not too high in rank. This appears to be increasingly true with coals of decreasing rank from medium volatile bituminous coals downward.

The article reflects the great emphasis placed on the technique of descriptive coal petrology in America. Such description has resulted in a good understanding of the nature of the fundamental variability in the physical composition of bituminous coals. Such understanding has been attained very largely by the thin section technique used in coal bed profile analysis introduced by R. Thiessen after the manner suggested by the data assembled in Table II.

In contrast, the group maceral concept of coal analysis in terms of the categories indicated on the left hand side of Fig. 4 is particularly useful for broken coal analysis and applied coal petrology, in which evaluation is largely based on quantitative concepts. It is inadequately emphasized in this article that although the Thiessen procedure is suitable for the purpose of petrologic description in which texture and orientation are of critical importance, it is less well adapted to the technological uses of applied coal petrology.

No doubt those persons whose interest may have been aroused in the possibilities of more refined coal preparation by this and other recent contributions to the literature of coal petrology will understand that certain technical aspects of coal petrology, particularly in the field of descriptive petrology, are still a matter of some controversy among the coal petrologists, but they will also appreciate that Schopf has made an important contribution to the field of coal petrology in America by pointing out that such petrology requires consideration of disoriented or broken coal samples and that results are expressed less in descriptive terms than in quantitative values with respect to the four types of material composing coal—vitrinite, exinite, inertinite, and mineral matter. Unfortunately because so much American coal petrology has been descriptive of the coal in the bed there is a dearth of literature on applied coal petrology. Research and experimental data in this field are greatly needed.

Grinding Ball Size Selection

by Fred C. Bond

SIZE of grinding media is one of the principal factors affecting efficiency and capacity of tumbling-type grinding mills. It is best determined for any particular installation by lengthy plant tests with carefully kept records. However, a method of calculating the proper sizes, based on correct theoretical principles and tested by experience, can be very helpful, both for new installations and for guiding existing operations.

As a general principle, the proper size of the make-up grinding balls added to an operating mill is the size that will just break the largest feed particles. If the balls are too large the number of breaking contacts will be reduced and grinding capacity will suffer. Moreover, the amount of extreme fines produced by each contact will be increased, and size distribution of the ground product may be adversely affected.

If the balls added are too small, grinding efficiency is decreased by wasted contacts that are too weak to break the particles nipped; these largest particles are gradually worn down in the mill by the progressive breakage of corners and edges.

Ball rationing is the regular addition of make-up balls of more than one size. The largest balls added are aimed at the largest and hardest particles. However, the contacts are governed entirely by chance, and the probability of inefficient contacts of large balls with small particles, and of small balls with large particles, is as great as the desired contact of large balls with large particles. Ball rationing should be considered an adjunct or secondary modification of the principle of selecting the make-up ball size to break the largest particle present.

Empirical Equation

In 1952[1,2] the author presented the following empirical equation for the make-up ball size:

$$B = \sqrt{\frac{F\,Wi}{K\,Cs}\sqrt{\frac{S}{\sqrt{D}}}} \qquad [1]$$

where

B = ball, rod, or pebble diameter in inches.
F = size in microns 80 pct of new feed passes.
Wi = work index at the feed size F.
Cs = percentage of mill critical speed.
S = specific gravity of material being ground.
D = mill diameter in feet inside liners.
K = 200 for balls, 300 for rods, 100 for silica pebbles.

Eq. 1 was derived by selecting the factors that apparently should influence make-up ball size selection and by considering plant experience with each factor. Even though Eq. 1 is completely empirical, it has been generally successful in selecting the proper size of make-up balls for specific operations. But an equation based on theoretical considerations should be used with more confidence and have wider application. The theoretical influence of each of the governing factors listed under Eq. 1 was accordingly considered in detail, as described below, and a theoretical equation for make-up ball sizes was derived.

F. C. BOND, Member AIME, is a Consulting Engineer with the Processing Machinery Dept., Allis-Chalmers Mfg. Co., Milwaukee.

TP 4728B. Manuscript, Oct. 10, 1957. Tampa Meeting, October 1957.

Derivation of Theoretical Equation

Ball Size and Feed Size: The basis of this analysis is that the largest ball in a mill should be just sufficient to break the largest feed particle into several pieces, excluding occasional pieces of tramp oversize. In this article the size F which 80 pct passes is considered the criterion of the effective maximum particle feed size. The smallest dimension of the largest particles present controls their breaking strength. This dimension is approximately equal to F.

As a starting point for the analysis it is assumed that a 1-in. steel ball will effectively grind material with 80 pct passing 1 mm, or with $F = 1000\mu$ or about 16 mesh. The breaking force exerted by a ball varies with its weight, or as the cube of its diameter B. The force in pounds per square inch required to break a particle varies as its cross-sectional area, or as its diameter squared. It follows that when a 1-in. ball breaks a 1-mm particle, a 2-in. ball will break a 4-mm particle, and a 3-in. ball a 9-mm particle. This is in accordance with practical experience, as well as being theoretically correct.

Confirmation of this reasoning is supplied by the Third Theory of Comminution,[3] which states that the work necessary to break a particle of diameter F varies as $F^{5/2}$. Since work equals force times distance, and the distance of deformation before breakage varies as F, it follows that the breaking force should vary as $F^{3/2}$. These relationships are expressed in Table I, with a 1-in. ball representing one unit of force and breaking a 1-mm particle.

Table I. Factors Relating Ball Size and Feed Size

Balls		Particles Broken		
Size, B Inches	Force, (Weight) B^3 Units	Size, F Millimeters	Size, Inches	Force, $F^{3/2}$ Units
1/2	1/8	1/4	0.00985	1/8
1	1	1	0.0394	1
2	8	4	0.157	8
3	27	9	0.354	27
4	64	16	0.630	64
5	125	25	0.985	125

This establishes theoretically the general rule used in Eq. 1 that the ball size should vary as the square root of the particle size to be broken.

Ball Size and Work Index: The work input W required per ton[3] varies as the work index Wi, and the

work input per particle of any size F also varies as Wi. Work equals force times distance (of deformation), and the distance does not necessarily or regularly vary with Wi. It follows that the breaking force varies as Wi. Since the force varies as B^3, and B^3 varies as Wi, the conclusion is that the ball diameter B varies as the cube root of the work index.

This does not agree with empirical Eq. 1, which states that B varies as $\sqrt{Wi}$.

Ball Size and Material Specific Gravity: Since the work input required per ton varies as the work index Wi and is independent of the specific gravity S, and since the number of particles per ton varies as $1/S$, it follows that at a constant Wi the work required per particle of any size F varies directly as the specific gravity S. The distance of deformation does not necessarily or regularly vary with S, so that the breaking force must vary as S. Since the force varies as B^3, it follows that B^3 varies as S. The conclusion is that the ball diameter B varies as the cube root of S.

This does not agree with empirical Eq. 1 which states that B varies as $S^{1/4}$.

Ball Size and Percent of Critical Speed: It is commonly accepted that within the practical operating speed range the work input to a mill is proportional to the percentage Cs of the critical mill speed. Since the work input per ball is proportional to B^3, at a constant work input B^3 is inversely proportional to Cs. It follows that the ball diameter B is proportional to the cube root of $1/Cs$.

This does not agree with empirical Eq. 1, which states that B varies as $\sqrt{1/Cs}$.

Ball Size and Mill Diameter: As the mill diameter D in feet inside the mill lining increases, at a constant percentage Cs of the critical speed the linear speed increases as $\sqrt{D}$ while the centrifugal force remains constant.

When the volume of the ball charge is maintained at a constant percentage of the mill volume, the weight of the ball charge increases as D^2, and the linear shell velocity increases as $\sqrt{D}$; it follows that the work input theoretically varies as $D^{5/2}$.

The number of balls of any size B varies as D^2, so that the work input per ball varies as $\sqrt{D}$, or as the linear speed of the mill. Since it has been shown that the work input per ball varies as B^3, it follows that the ball diameter B is proportional to the cube root of $\sqrt{1/D}$, or to $(1/D)^{1/6}$.

This does not agree with empirical Eq. 1, which states that B varies as $(1/D)^{1/4}$.

The above analysis neglects the special case of large diameter mills using small balls. When the make-up ball diameter B becomes less than about 1 pct of the mill diameter $12D$ in inches, a *slump factor* appears, and the work input increase with diameter falls below $D^{5/2}$. It apparently approaches $D^{3/2}$ as a limit; under these limiting conditions the effective work input is confined by ball slippage to a zone near the mill lining, and the active ball zone thus becomes proportional to D rather than D^2. The work input thus approaches $D \times \sqrt{D}$, or $D^{3/2}$, as a limit. However, the limiting number of active balls of any size B varies as D instead of D^2, so that the proper ball diameter B remains proportional to the cube root of $\sqrt{1/D}$, as in the above analysis.

Theoretical Ball Size Equation: As a result of the above factor analysis, the following theoretical equation, Eq. 2, can now be written for the proper make-up ball size B, using $1/K$ as the proportionality constant as in empirical Eq. 1:

$$B = \left(\frac{F}{K}\right)^{1/2} \left(\frac{S\,Wi}{Cs\sqrt{D}}\right)^{1/3} \qquad [2]$$

Selected average values of the proportionality constant K have been determined empirically and are listed in Table II.

Table II. Tumbling Mills

Grinding Media	Steel or C.I. Balls K	Silica Pebbles K
Wet—Overflow—Open Circuit	350	—
Wet—Overflow—Closed Circuit	350	—
Wet—Diaphragm—Open Circuit	330	170
Wet—Diaphragm—Closed Circuit	330	170
Dry—Diaphragm—Open Circuit	335	175
Dry—Diaphragm—Closed Circuit	335	175

Selection of Proper Size of Make-Up Balls

After the ball diameter B in inches has been calculated from Eqs. 1 and 2, the nearest commercial ball size is selected to be fed to the mill in sufficient amount to compensate for ball wear. However, when the value of B is 1 in. or smaller, somewhat larger balls may be preferable for the following reasons:

1) Since the small balls cost more per ton, the total grinding cost per ton may be decreased by using slightly larger balls, even though they are mechanically less efficient.

2) When the small balls are to be used in a large diameter mill, slightly larger balls will increase the power drawn by the mill and may increase the mill capacity.

3) In diaphragm discharge mills the small balls may tend to blind the grate openings and may increase ball wear per ton ground by discharging at too large a size.

Eq. 2 is preferred to Eq. 1 because of its theoretical derivation. However, in most instances both equations will probably indicate the same commercial ball size selection. This is shown in Table III, where B values are calculated from both equations for several values of the controlling factors for wet overflow ball mills.

Table III. Ball Size Calculations

Factors					Eq. 1	Eq. 2
F	Wi	S	Cs	D	B	B
500	12	2.7	76	9.0	0.613	0.625
1000	15	3.0	75	10.0	0.990	0.973
2000	10	3.3	65	12.0	1.229	1.265
5000	13	2.9	77	8.0	2.07	2.11
10000	11	2.8	70	11.0	2.69	2.73

Rod Size Selection

Since each rod in a rod mill makes an indeterminate number of particle contacts, no theoretical derivation of the equation for proper rod sizes was attempted. The make-up rod size selection should be based on empirical Eq. 1, using the constant K equal to 300.

Ball and Rod Weights and Surface Areas

The weight, volume, surface area, and number of grinding balls or feet of grinding rods, of diameter

Table IV. Ball and Rod Data

Balls, No., or Rods, Ft	Pounds	Cubic Feet	Surface Area, Sq In.
One ball	$0.148B^3$	—	$3.142B^2$
$13,500/B^3$ balls	2000	6.89	$42,500/B$
$1960/B^3$ balls	290	One	$6160/B$
Equilibrium charge fed with B balls	2000	6.89	$57,500/B$
1-ft rod	$2.67B^2$	—	$37.8B$
$750/B^2$-ft rods	2000	5.13	$28,400/B$
$146/B^2$-ft rods	390	One	$5510/B$
Equilibrium charge fed with B rods	2000	5.13	$30,000/B$ (approx)

B inches, can be calculated from Table IV. The pounds per cubic foot of grinding balls range from fewer than 280 for rough cast iron balls to 300 for well-rounded forged steel balls.

Start-Up Grinding Media Charges

When a grinding mill operates for several months with a constant size of make-up media added and a constant size of worn media discharged, an equilibrium size distribution of the grinding media is established which will continue indefinitely. This equilibrium is established more quickly in wet mills than in dry mills because of the greater media consumption per ton ground in wet mills.

The equilibrium depends on the generally accepted rule of equal film wear in equal grinding time. A film of equal thickness will be removed from all sizes of balls or rods in a mill during any grinding period, excluding ball or rod breakage.

According to this rule, when the ball or rod diameter is plotted as abscissa, and the percent weight passing that diameter is plotted as ordinate on log-log paper, the equilibrium size distribution will be represented by a straight line with a slope m of 3.84 for grinding balls and 3.01 for grinding rods.

It is desirable, particularly in wet grinding mills, that the initial ball or rod charge used in starting up a new mill should be similar to the equilibrium charge, in order that grinding results at the start-up will be about the same as those when the circuit has reached continuing equilibrium. The initial charge cannot be precisely the same as the equilibrium charge, since it is made up of only a few sizes of balls or rods, but the relative weight of each size can be selected so that it approximates the equilibrium charge. The proper proportions are determined as shown in Table V.

A straight line is drawn on log-log plotting paper starting at 100 pct passing the known make-up size at the top of the sheet, with a slope of 3.84 for balls and 3.01 for rods. Vertical lines are drawn representing the mid-points between the ball or rod sizes available. The intersections of these lines with the equilibrium distribution line determine the percent weight of each size to be used in the initial charge.

Tables V and VI, opposite, show initial ball and rod charges to be used when make-up balls or rods of the designated size are to be fed. When two or more make-up media sizes are to be used in a fixed proportion for ball rationing, each portion of the initial charge is calculated from its own make-up ball or rod size.

The situation is somewhat different in dry-grinding single-compartment ball mills, particularly when they are grinding soft materials such as limestone or cement raw material, or materials such as cement clinker, in which the larger particles have a lower work index. Here the ball wear is only one fifth to one tenth that in wet grinding, and two or three years may be required to reach equilibrium.

Table V. Start-Up Equilibria Grinding Ball Charges, Percent Weight

Make-Up Balls Fed Sizes, In.—B	4½ In.	4 In.	3½ In.	3 In.	2½ In.	2 In.	1½ In.
4½	23.0						
4	31.0	23.0					
3½	18.0	34.0	24.0				
3	15.0	21.0	38.0	31			
2½	7.0	12.0	20.5	39	34		
2	3.8	6.5	11.5	19	43	40	
1½	1.7	2.5	4.5	8	17	45	51
1	0.5	1.0	1.5	3	6	15	49
Total, pct	100.0	100.0	100.0	100	100	100	100

Table VI. Start-Up Equilibria Grinding Rod Charges, Percent Weight

Make-Up Rods Fed Sizes, In.—B	5 In.	4½ In.	4 In.	3½ In.	3 In.	2½ In.
5	18					
4½	22	20				
4	19	23	20			
3½	14	20	27	20		
3	11	15	21	33	31	
2½	7	10	15	21	39	34
2	9	12	17	26	30	66
Total, pct	100	100	100	100	100	100

In these cases the initial charge should contain a larger proportion of small balls than the equilibria charges listed above, and this proportion should be maintained by adding a rationed charge of make-up balls. The exact proportion depends on the size distribution and composition of the material fed, and no general rule has been established, except that at least half the make-up balls added should be smaller than the size B calculated from Eq. 1 or Eq. 2.

In dry grinding mills of two or more compartments, each compartment is considered a separate mill, and the make-up ball size B for each compartment is calculated from Eq. 1 or Eq. 2. The size F of the feed entering each compartment can be calculated from the fraction of the total power input drawn by the preceding compartments.

Amount of Make-Up Grinding Media Required

The amount of make-up grinding media that must be added regularly to a mill to maintain a constant volume of grinding charge and a constant power input will vary with the character of the metal and the abrasiveness of the material being ground.

Table VII. Ball and Rod Wear Replacement

	Wet		Dry	
	Kw-hr Pound	Lb Day 100 Hp	Kw-hr Pound	Lb Day 100 Hp
Grinding balls	6	300	35	50
Grinding rods	5.5	325	30	60

However, it is primarily dependent on the power input to the mill, and estimates of the amount required for new installations should be based upon the power.

Table VII lists the average kilowatt-hours per pound of metal worn away and discharged and the average pounds of make-up balls and rods required per 24-hr day for each 100 hp drawn by the mill, when it is grinding silicious materials. Dry grinding of limestone will require perhaps half the amounts listed for silicious materials. Because of the wide variations in materials and metals these values should be used for rough estimating purposes only.

Summary

Empirical and theoretical equations are given for calculating the proper sizes of balls and rods to be added regularly to tumbling grinding mills. Both equations give similar results.

A convenient table of ball and rod weights, volumes, and surface areas is given, and tables of the proper ball and rod size distribution for starting up a mill are included. Rough estimating figures for ball and rod wear are given.

References

[1] F. C. Bond: Mathematics of Crushing and Grinding. In *Recent Developments in Mineral Dressing*. Published by Institute of Mining and Metallurgy, Salisbury House, London, 1953.

[2] F. C. Bond: Crushing and Grinding Calculations. *Canadian Mining and Metallurgical Bulletin*, vol. 47, no. 507, July 1954, *Trans.*, vol. LVII, 1954, pp. 286-292.

[3] F. C. Bond: Third Theory of Comminution. *AIME Trans.*, 1952, vol. 193, pp. 484.

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Discussion

Mineralizing Solutions That Carry and Deposit Iron and Sulfur

by B. S. Butler

(MINING ENGINEERING, page 1012, October 1956, AIME Trans., vol. 205)

A. D. Mutch *(Falconbridge Nickel Mines Ltd., Onaping, Ontario)*—This contribution is prompted by the fact that the writer has recently published an article[29] which has in part the same general conclusions as B. S. Butler's, namely, the form of the standard mineral paragenesis in hypogene deposits and the parallel transition from early high temperature acid to late low temperature alkaline or neutral solutions. Since the writer also recognizes that he is not fully qualified to discuss the formation of ore deposits as a chemical problem, this discussion will be limited to summarizing other observations and will suggest how Butler's Table II might be made more effective.

The form of Butler's table is not unlike that widely used by European geologists[30] in which the various minerals are related to the types of ore fluids—pegmatitic, pneumatolic and hydrothermal. Thus the decrease in temperature and change in pH of the ore-bearing fluids as recognized by Butler may also be paralleled by perhaps even greater changes in composition, density, and character.

W. H. Newhouse's article[31] on the sequence of hypogene ore mineral deposition is still one of the most complete analyses of the problem. In it he makes four major observations:

1) The order of O, S, As, Sb is the same as their increasing atomic weights and the same as their melting points.

2) The order of the metallic elements is the same as the Schuermann series.

3) The general mineralogical order is paralleled by decreasing heats of formation.

4) The order is generally in decreasing hardness, higher metal content, and higher specific gravity.

The order of O, S, As, and Bi is also the same as their relative abundance. Another point worth mentioning about this series is that As, Sb, Bi, when abundant, often substitute for sulfur in the early pyrite-like minerals, whereas later in the sequence these elements appear to act more like metals. This behavior may be a further indication of the acid character of the early fluids.

C. J. Sullivan[32] has attempted to show that the sequence of the metallic elements is related to the order of their melting points and has discussed the interrelationship of the different types of bonding of sulfophile and oxiphile elements in minerals.

Items 3 and 4 might best be summarized by saying that bonding of the minerals in the series appears to be from ionic to covalent to metallic, the early minerals being light in weight, hard, and near-transparent; the intermediate minerals of intermediate weight, semi-transparent, and semi-conducting; and the end minerals heavy, soft, and malleable, opaque and good conductors.

A rapid fall in temperature has been assumed to be the cause of ore deposition in many deposits. Perhaps this in turn is the effect of a rapid release of energy in the form of pressure release and change of volume, the first minerals to form being those with the highest heats of formation which absorb the released energy the most rapidly.

Butler's Table II could probably be streamlined and made more effective if the listed compounds were assembled as mineralogical groups as in Dana.[33] Thus the sulfides, arsenides, antimonides, bismuthides, and sulfa salts could be arranged in AX_2, AX, A_2X_3, etc. groups. Since these are continuous substitution series, in which the fields of stability and the heats of formation of the various individual minerals can be fairly regarded as similar, this should be accomplished with no loss of clarity. The occurrence of the individual minerals and the precise sequence of the mineral deposition in any one deposit is probably more dependent on the concentration and relative abundance of the component elements.

The assembling of geological data in tabular form such as Butler's Table II will continue to be a very effective method of studying geological phenomena. The importance of this particular problem has been pointed out by C. F. Park,[34] who concludes that understanding of mechanisms of the standard paragenesis and interrelated problems of mineral zoning in space and time is one of the major keys to classification of ore deposits.

References

[29] A. D. Mutch: A Critical Evaluation of the Classifications of Ore Deposits of Magmatic Affiliations. *Economic Geology*, 1956, vol. 51, pp. 665-685.

[30] P. Niggli: *Ore Deposits of Magmatic Origin* (trans. H. C. Boydell). Thomas Murby, London, 1929.

[31] W. H. Newhouse: The Time Sequence of Hypogene Ore Mineral Deposition. *Economic Geology*, 1928, vol. 23, pp. 647-659.

[32] C. J. Sullivan: Metallic Melting Point and Ore Deposition. *Economic Geology*, 1954, vol. 49, pp. 555-574.

[33] C. Palache, H. Berman, and C. Frondel: Dana's *System of Mineralogy*, vol. 1. John Wiley & Sons Inc., New York, 1944.

[34] C. F. Park, Jr.: Zonal Theory of Ore Deposits. *Economic Geology*, 1955, 50th Anniversary Volume, pp. 227-248.

Discussion

Filtration and Control of Moisture Content on Taconite Concentrates

by A. F. Henderson, C. F. Cornell, A. F. Dunyon, and D. A. Dahlstrom

(*MINING ENGINEERING*, page 349, March 1957, *AIME Trans.*, vol. 208)

Ossi E. Palasvirta *(Development Engineer, Oliver Iron Mining Div., U. S. Steel Corp.)*—The authors are to be congratulated for their interesting article, which thoroughly illustrates the variables inherent in filtration of taconite concentrate. The work and the conclusions based thereon largely parallel the test work done by the writer at the Pilotac plant* and the experience gained with a commercial size agitating disk filter in the same plant. At Pilotac, however, a thorough study was also made of the effect of depolarizing (demagnetizing) the filter feed, and it is the purpose of this discussion to comment on the merits of depolarization of the magnetite concentrate prior to filtering.

The work at Pilotac was done in three phases: 1) preliminary laboratory testing with a circular filter leaf of 0.047 sq ft, followed by 2) plant testing using a 4-ft diam, single-disk agitating filter that was purchased on the basis of the pilot tests on the 4-ft model. In the laboratory tests depolarization was achieved by slowly withdrawing[1] batches of thickened concentrate from a coil producing an alternating field of about 300 oersteds. In plant tests the standard Pilotac procedure[1] was employed, wherein the pulp falls freely through the depolarizing coil.

The preliminary tests in the laboratory at first seemed to indicate that although depolarization of the filter feed decreases the cake moisture, it also tends to decrease the thickness of the cake, thus decreasing filtering rate. The tests with the 4-ft disk filter soon showed, however, that the compactness of the cake, attained during the form period because of depolarization, permitted a considerable decrease in drying time without any sacrifice in final moisture content. Thus, the filter could be operated at a much higher speed, and the overall capacity was higher than with magnetized feed. Because of the great compactness of the cake there was little shrinkage during the drying period, which prevented cracking and subsequent loss in vacuum. This in turn permitted operation with as thick a feed pulp as the diaphragm pumps could handle, eliminating the necessity of pulp density control.

On the basis of these findings, the 6-ft agitating disk filter has been operated at 2 rpm, using feed pulps varying from 65 to 73 pct solids. Initially Saran 601 was used as medium, but it was later replaced with a relatively open, tight-twist nylon cloth. Filtering rates up to 750 lb per ft^2 per hr can be attained with feeds averaging about 70 pct -270 mesh, and there is no trouble because of cracking. The cake moistures vary between 8.5 and 9.5 pct.

To recapitulate, the merits of depolarizing the filter feed may be summed up as follows:

1) The well dispersed pulp shows less tendency to settle in the filter tank.

2) The homogeneous filter pool results in more even cake formation.

3) Because of absence of flocs, great compactness of cake is attained during the form period.

4) The cake does not tend to crack during the drying period.

5) A drier cake is produced.

6) A shorter drying period is necessary, permitting higher operating speed, which in turn results in increased capacity.

7) Density of the feed pulp can be kept as high as the equipment can handle. This increases capacity, since it is directly proportional to the percentage of solids in the pool.

A few tests were also made to study the effect of chemical flocculants on filtration efficiency. Results showed that the effects of chemical and magnetic flocculation were quite similar. Thus the use of a flocculant would impair rather than improve the filtering of magnetite concentrate.

* Pilotac plant, Mt. Iron, Minnesota, Oliver Iron Mining Div., U. S. Steel Corp.

A. F. Henderson, C. F. Cornell, A. F. Dunyon and D. A. Dahlstrom *(authors' reply)*—We want to thank O. E. Palasvirta for his comments, particularly in view of the encouraging results obtained with demagnetized taconite concentrate. In our studies an attempt was made to evaluate the effects of depolarizing the feed to the plant filters by passing the slurry through a coil, similar to the method described by Palasvirta. Unfortunately, in our experiments there were no startling improvements in performance level, neither cake rate increase nor cake moisture reduction. However, when slow filter cycle speeds were employed, the filter cake tended to crack and the vacuum level dropped, resulting in an increase in cake moisture content. When demagnetized feed was used during slow speeds, no cake cracking was evidenced and the vacuum level remained constant. Thus the depolarizing coil was found necessary only in cases of cracking.

It should be noted that most of our test work concerned a feed of 85 to 90 pct -335 mesh and about 60 pct by weight solids concentration. This contrasts with 70 pct -270 mesh and 65 to 73 pct by weight solids as noted by Palasvirta. Reviewing both sets of results, it might be concluded that depolarizing may be successfully employed to alleviate cake cracking tendencies and may markedly improve cake rates and moistures on the coarser taconite concentrates. Further investigations may disclose the exact relationship of grind and pulp density to the depolarizing action.

Reference

[1] M. F. Williams and L. G. Hendrickson: Depolarizing Magnetite Pulps. *AIME Trans.*, 1956, vol. 205, p. 201.

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Page 598

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Any recent activity that would be of interest to members:

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It is particularly appropriate that this first edition of the *Coal Division News* be devoted to the work of the scholarship committee. Their work is typical of the role of the Coal Division as a meeting ground where industry leaders have an opportunity to know the leaders of the day after tomorrow—and the younger men have an opportunity to meet and know the leaders of today and tomorrow.

A measure of the statesmanlike job being done by the scholarship committees lies in their concern not only with the immediate calibre of the students, but particularly with the ultimate ability of these young men to serve industry in places of leadership.

Projects of this type coupled with national technical programs are part of the Coal Division's unique position in providing a common ground for leader and neophyte—for executive and engineer.

The *Coal Division News* can develop into an important forum for all of us. The Division welcomes this chance to reach its wide membership each month and urges each member to contribute items of interest to other members of the Division. Address your letters to Coal Division News, c/o MINING ENGINEERING, 29 West 39th St., New York 18, N. Y.

Scholarship Selection Committee

Scholarship activities of the Division are under two-pronged administration. The Scholarship Fund Committee, directed by Hugo Nyquist, chairman, is responsible for maintaining the Division student aid funds and increasing them whenever possible.

Selecting student recipients and following their progress is the job of the Scholarship Selection Committee, headed by Charles E. Lawall, chairman, and M. D. Cooper, co-chairman. Working with them are Edward A. Dines, R. T. Gallagher, G. Ralph Spindler, and Ernest M. Spokes. The four committeemen represent various universities in the coal area: respectively, University of Pittsburgh, Lehigh University, West Virginia University, and University of Kentucky.

In the annual report of the Scholarship Fund Committee, given at the Annual Meeting in February, it was announced that the fund balance stands at $2,941. Since this is the balance after two students now in school had received their full yearly allotment, the Division will be able to select several students for the terms beginning in the fall of 1958. Applications are already being received.

Over the past few years, 18 students have been helped in their educational plans. The scholarships, which are usually given over a four-year period with the understanding that satisfactory records must be maintained, are divided as follows: $300, freshman year; $350, sophomore year; and $400 each for the junior and senior years. Limited funds have kept the number of scholarships below what the committee would have liked.

Of the 18 students who received or who are receiving aid, 12 graduated or are studying mining engineering in the coal field. Two of this group are now serving in the armed forces; the rest are working in the coal industry or are still in college, with the exception of one graduate now employed in the copper industry and one who is now a graduate student in geology after working in coal.

The record of the students who continued under the program has been good. Those who dropped out or transferred did not, with a few exceptions, make as good records. The committee feels that the young men who ultimately enter the coal industry will rise to places of responsibility and leadership.

Richard C. Welch and Donald R. Morrow are the current holders of scholarships from the Coal Division.

Mr. Welch, son of Mr. and Mrs. Carl F. Welch, Uniontown, Pa., is a sophomore at the Pennsylvania State University, enrolled in mining preparation engineering and specializing in coal preparation. A graduate of Mercer Joint Consolidated High School, Mercer, Pa., he is a member of the AIME Student Chapter at Penn State. At the University, Mr. Welch is a member of Tau Kappa Epsilon; Alpha Pi Omega, service fraternity; and an associate editor of Penn State Interfraternity Counsel Rushing Magazine.

Donald Roy Morrow, who is expected to graduate in August with honors, is a senior in the Mining Engineering Dept. at the University of Pittsburg. Married, 27 years old, and a native of Butler, Pa., he is a veteran of four years service in the U. S. Air Force. At Pittsburgh Mr. Morrow is president of the AIME Student Chapter and class representative of the Engineering and Mines Cabinet. In addition to his Coal Division scholarship, he holds a research aid grant in the Ore Dressing Laboratory at the University. Mr. Morrow will be the recipient of an Old Timers award in June.

Meetings

The Coal Division will participate in two regional meetings in addition to the February 1959 Annual Meeting in San Francisco. A joint meeting is planned for June 13 and 14 with the AIME Central Appalachian Section at Lexington, Ky. The Division will also co-sponsor, with the ASME Fuels Div., the Joint Solid Fuels Conference at Old Point Comfort (near Norfolk), Va., October 9 and 10.

Lexington Meeting

At the June 13 and 14 joint meeting of the Central Appalachian Section and the Coal Division, three sessions of interest to Division members will be held. Among the topics to be covered are: economic aspects of stream pollution; shafts vs slopes for deep mines; cable belt developed in Scotland; sealing around oil and gas wells in a coal field; compilation and review of capital and operating costs for heat drying coal with several of the various methods and types of equipment; new oil fields in the western part of Breathitt County, Ky.; hydraulic mining of gilsonite; and transportation in and around the mine. Two luncheons, one social hour, and a dinner will be part of the meeting, and people prominent in the mining industry will speak.

There will also be three separate sessions for the nonfuels members of the Section. Subjects to be covered include: water problems in mining, phase of the DMEA program, fluorspar and clayshale resources of Kentucky, Salem limestone, and lightweight aggregates.

Fuels sessions program chairman is Carel Robinson and John C. Ludlum and Keith Lupton are co-chairmen for the nonfuels program. Ernest M. Spokes is in charge of overall arrangements and should be contacted if difficulties are encountered in making reservations. His address is University of Kentucky, Lexington, Ky.

H. C. WEED

L. H. HART

This month *Rock in the Box* is a salute and an introduction—a salute to the hardworking officers and unit chairmen of Mining and Exploration Division and your introduction to them. The executive committee of the Division is composed of the officers (chairman, assistant chairman, vice chairmen, and secretary), the unit committee chairmen, and Clark L. Wilson, past-chairman of the Division and head of the nominating committee.

Chairman—*H. C. Weed*, a native of Michigan, graduated from Michigan College of Mines. After a short stint for Calumet & Hecla Mining Co., he joined United Verde Copper Co. in Jerome, Ariz. Since 1937 he has been associated with Inspiration Consolidated Copper Co. in Inspiration, Ariz., recently becoming general manager for Arizona operations. His address: Inspiration Consolidated Copper Co., Inspiration, Ariz.

Assistant Chairman—*Lyman H. Hart* hails from Iowa and is a graduate of the University of Wisconsin with B.S. and M.S. degrees. His early years in the mining business were spent with The Anaconda Co. in Butte. He is now chief geologist for American Smelting and Refining Co. His address: American Smelting and Refining Co., 120 Broadway, New York 6, N. Y.

Vice Chairman (Publications)—*John G. Hall*, a graduate of the University of Utah, is a native Nebraskan. Mr. Hall joined National Lead Co. as assistant plant manager of the Tahawus, N. Y., titanium plant. He became manager in 1955. His address: National Lead Co., Tahawus, N. Y.

Vice Chairman (Program)—*Robert J. Lacy* is chief geophysicist for American Smelting & Refining Co., Salt Lake City. After graduating from the University of Minnesota in 1937, he became geologist for The Anaconda Co. in Butte, later joining the California Co. as a geological observer. His address: American Smelting & Refining Co., 600 Crandall Bldg., Salt Lake City 1, Utah.

Vice Chairman (Membership), **Geophysics Unit Chairman**—*Herbert E. Hawkes, Jr.*, a New Yorker and Dartmouth graduate, spent three years in Canadian exploration geology and geophysics before returning to Massachusetts Institute of Technology for a Ph.D. Mr. Hawkes had been associated with USGS and the MIT faculty before he went to Berkeley in 1957 to become a member of the staff at the University of California. His address: University of California, Div. of Mineral Technology, Berkeley 4, Calif.

Secretary—*James L. Carne* is the hardworking M&E secretary—and a modest man. Chief mine engineer for Inspiration Consolidated Copper Co., he reports that he joined the company in 1922 as a mucker. His address: Inspiration Consolidated Copper Co., Inspiration, Ariz.

Underground Mining Unit Chairman—*J. M. Ehrhorn* is a graduate of Stanford University. Among the companies for whom he has worked are United Verde Copper Co., Western Knapp Engineering Co., and U. S. Smelting Refining and Mining Co. where he became industrial development director in 1953. His address: U. S. Smelting Refining & Mining Co., P.O. Box 1980, Salt Lake City, Utah.

Rock in the Box Editor

Address news items to: John W. Chandler, American Metal Climax Inc., 61 Broadway, New York 6, New York.

Open Pit Mining Unit Chairman—*W. A. Pakkala*, a graduate of Michigan College of Mining and Technology, has spent his career on the Mesabi Range. He worked for Ahmeek Copper Mines and Pickands Mather & Co. before joining The Cleveland-Cliffs Iron Co. in 1942. Mr. Pakkala is now general superintendent. His address: The Cleveland-Cliffs Iron Co., Hibbing, Minn.

Geology Unit Chairman—*W. W. Simmons* is chief geologist for Miami Copper Co., Miami, Ariz. Holder of an M.S. degree from the University of Arizona, he worked for a number of companies including Tennessee Copper Co. and the USGS before going to Miami. His address: Miami Copper Co., Box 100, Miami, Ariz.

Geophysics Unit Chairman—*Robert J. Searls*, a native of California, attended Cornell University and Colorado School of Mines. Now with Newmont Mining Co., he had been associated, at various times, with Subungwe Mining & Exploration in South Rhodesia and Mining Research Co. His address: Newmont Mining Co., 300 Park Ave., New York 22, N. Y.

Executive Committeeman—*Clark L. Wilson*, Division past-chairman, is vice president and director of New Park Mining Co. Mr. Wilson holds degrees from the Universities of Utah and Arizona. His address: New Park Mining Co., 904 Walker Bank Bldg., Salt Lake City, Utah.

J. G. HALL

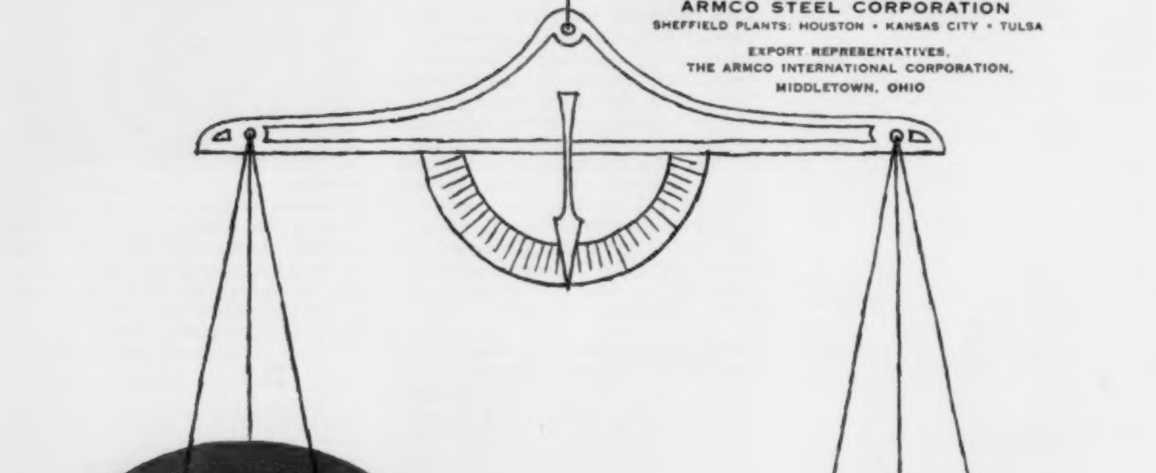
R. J. LACY

H. E. HAWKES, JR.

J. M. EHRHORN

W. W. SIMMONS

C. L. WILSON



New York Annual Meeting 1958

ARCTIC conditions decorated the New York scene during this year's Annual Meeting in February. Snarled travel conditions and near-record snowfall conspired to prevent many from reaching the city for the opening events of the meeting, but in spite of biting cold and snow-piled streets, over 3500 made the trip, including about 500 ladies.

New York in 1958 marked the first anniversary of the *new look* for AIME, with the constituent societies—Society of Mining Engineers, Society of Petroleum Engineers, and The Metallurgical Society — each holding full programs highlighted by reports of outstanding developments in their respective fields. Continued this year was the All-Institute Technical Session, a New Orleans innovation which proved so popular that it became a permanent feature of Annual Meetings.

Weekend Activities

Activities began on Saturday despite an all-night and all-Sunday snowfall with meetings of the Boards of Directors of the Societies, annual meeting of the All-Institute Membership Steering Committee, and the lively Council of Section Delegates meeting on Saturday. Sunday was education day for the three groups, each of which held a separate session in the afternoon. Sunday evening the three Societies joined as the AIME Council of Education for buffet supper. Featured speaker of the evening was AIME Vice President Roger V. Pierce who discussed *The Mineral Engineer—And What's Next?* Highlight of the dinner was the presentation of the second Mineral Industry Education Award to Charles E. Lawall, Society of Mining Engineers Vice President and outstanding educator in the mineral industry field.

The afternoon sessions reflected the general *soul-searching* on education problems that has prevailed in this country since the launching of the first Russian Sputnik. The mining group was concerned with curriculum deficiencies and the sharp competition for qualified engineers, and the petroleum engineers also showed their interest in the discussion of the ECPD plan for a five-year program for professional development. Some of the leaders of the metallurgical profession were among the American group who toured Russia last summer and undoubtedly their observations colored the discussion of professional training and need for developing scientific *brainpower*.

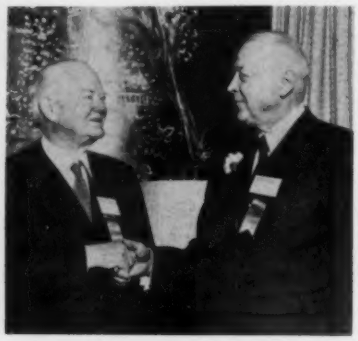
Welcoming Luncheon

After a busy weekend of session and committee meetings the AIME Annual Meeting formally opened on Monday with technical sessions and the noon Welcoming Luncheon. Detlev Bronk, distinguished president of the National Academy of Sciences and National Research Council and president of the Rockefeller Institute for Medical Research, was the principal speaker. Luncheon festivities included recognition of outstanding achievement in membership affairs by Local Sections. President's Banner awards went to five Sections, one each from five categories, and once again the roster was predominated by petroleum groups. Winners for submitting the greatest number of membership applications in proportion to their membership were the Upper Mississippi Valley, Western Venezuela, Denver Petroleum, Permian Basin, and Dallas Sections. Gavel awards went to Sections submitting the largest number of applications in relation to other Sections within their groups—Caracas, Western Venezuela, Denver Petroleum, and Permian Basin. The Gulf Coast Section, which had won a gavel in a previous year, was presented with a plaque.

Prizes in Institute's sixteenth National Student Prize Paper Contest went to representatives from each of the three Societies. Society of Mining Engineers' winners included Moshe Sheinkin in the undergraduate division and William M. Dolan

America's satellite program and its connection with *Push Buttons in Modern Warfare* was the theme of Col. C. G. Patterson at the All-Institute Technical Session on Tuesday.

One of the highest honors AIME can confer is Honorary Membership in the Institute. Shown here are Champion Mathewson, Donald MacLaughlin, and Fred Searls, Jr., enjoying congratulations from Past-President Grover J. Holt.



Annual Meetings provide a chance for old friends and colleagues to get together. Here the Hon. Herbert Hoover and Scott Turner, both AIME Past-Presidents, exchange greetings.

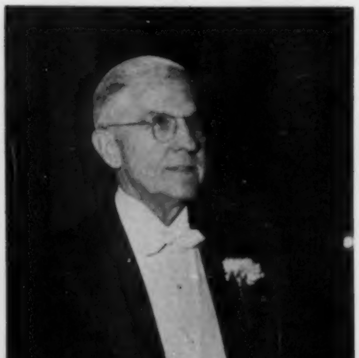
in the graduate division. (For further information, see page 603.) W. J. Babyak was the undergraduate division winner from The Metallurgical Society. Society of Petroleum Engineers' winners were S. W. Mason, undergraduate, and James E. Dunegan, graduate.

Also awarded at the luncheon were prizes for Student Chapters submitting the greatest number of Student Associate applications during the period Sept. 1 to Dec. 31, 1957. First prize of $100 went to the group at Texas Technological College. Five runner-up awards of a banner went to University of Wyoming, Texas A & I, University of Houston, University of Oklahoma, and Syracuse University.

Monday evening initiated the social events when everyone gathered for the All-Institute cocktail party in the Skytop and Penntop of the Statler Hotel. This was followed by the dinner-smoker, a strictly stag affair with floor show.

All Institute Session

Push Buttons in Modern Warfare, a most timely topic for this satellite age, was the address by Col. Charles G. Patterson of the Army's Redstone Arsenal at the All-Institute Technical Session on Tuesday afternoon. Speaking to a capacity crowd, with vivid color films in the background, Colonel Patterson spoke of the Army's pride in its Explorer satellite, launched only a few weeks before the AIME meeting. In parallel to the constructive concern of the educators was his emphasis that it takes knowledge to push the button —if you expect results. His remarks, "Our philosophy is—the future belongs to those who prepare for it. We realize you can't do today's job



Personalities make news at AIME Annual Meetings. Charles E. Lawall, SME Vice President, was honored for his contributions to education when he received the second Mineral Industry Education award on Sunday Evening. One of the recurring themes of the meeting—engineering education and its problems—was highlighted in the Welcoming Luncheon speech made by Detlev Bronk, center. Incoming President Augustus B. Kinzel was snapped in a moment of relaxation from the rigors of the week-long meeting.

with yesterday's tools, equipment, and procedures and expect to be in business," might be the keynote theme for the Annual Meeting itself.

The annual business meeting of AIME immediately followed the All-Institute session. President Grover J. Holt brought the membership up-to-date on the happenings of the past year, emphasizing progress made toward the construction and establishment of the new United Engineering Center (see pages 558 and 559 for illustrations.)

Society Dinners

Tuesday evening was Society Night—with each of the three Societies holding their annual dinners before retiring to the Grand Ballroom of the Statler Hotel for a session of music, dancing, and general relaxation.

Annual Banquet

The Institute took a pause on Wednesday and used the occasion to honor some of the outstanding men in its field of engineering. It was also change of command, for the Annual Banquet marked the official end of Grover J. Holt's term as President of AIME and the installation of Augustus B. Kinzel as incoming President. Among those honored, three men—Donald H. McLaughlin, Champion H. Mathewson, and Fred Searls, Jr.—were singled out for special recognition when they were made Honorary Members of AIME. Other awards given at the Banquet included: James Douglas Gold Medal to J. Roy Gordon, William Lawrence Saunders Gold Medal to William Jesse Coulter, Charles F. Rand Gold Medal to John F. Thompson, Anthony F. Lucas Gold Medal to Carl E. Reistle, Jr., Robert H. Richards Award to Fred D. DeVaney, and Benjamin F. Fairless Award to Hjalmar W. Johnson. Two AIME men this year were among recipients of the four Founder Society awards—the John Fritz Medal to John R. Suman and the Hoover Medal to Scott Turner. Grover J. Holt was toastmaster for the evening and his last official act was to introduce Mr. Kinzel who gave a brief address. The Presidential receiving line formed after dinner and dancing climaxed the evening.

Student Prize Paper Award
Society of Mining Engineers Graduate Winner

WILLIAM M. DOLAN, graduate student prize paper contest winner of the Society of Mining Engineers, was a graduate student and research and teaching assistant in the Geophysics Dept. of the University of Utah at the time he submitted his prize-winning paper. A graduate of the University of Utah with a B.S. in geophysics in 1956 and an M.S. in 1957, he is married and has two children, Mr. Dolan, who served in the Navy Air Force from 1948 to 1952, is now employed by Newmont Exploration Ltd. He had gained professional experience during his summer vacations. Among the firms with whom he had been associated are Walker-Lybarger Construction Co. (AEC contractor), as a helper on geophysics crews; Boyles Brothers Drilling Co., as superintendent of a small uranium operation; and Newmont Exploration Ltd., as an exploration geophysicist in New Brunswick, Canada. Mr. Dolan left the University of Utah in April 1958.

Abstract of Location of Geologic Features by Radio Ground Wave Measurements in Mountainous Terrain

Researchers in the past have had significant success in locating near-surface geologic features by observing the variations in broadcast radio ground wave intensities over these features. However, all work was done in regions of little or no topographic relief. Topography has a distinct effect upon ground wave propagation and thus an investigation of the method in a region of mountainous terrain was warranted.

Radio field intensity measurements were made in the East Traverse Range, at the border of Utah and Salt Lake Counties, Utah, using the fields of seven different radio stations at different locations. The results indicate that the effects on the radio signals due to geology can be resolved from those due to topography by using the technique of measuring the field intensities of radio stations in cpposite directions at each field station along a traverse.

Radio intensity anomalies of about 2500 microvolts per meter were observed along profiles across the Wasatch fault zone and the inferred fault on the northern margin of the East Traverse Range.

There comes a time when the prominent men can enjoy AIME Annual Meetings without the cares of organization or office. Gathered for the Past-Presidents' Luncheon on Thursday were, left to right, standing: Grover J. Holt, Michael L. Haider, Andrew Fletcher, H. DeWitt Smith, W. M. Pierce, Leo F. Reinartz, and Clyde Williams. Seated and flanking the Senior Past-President Herbert Hoover are, left to right, C. H. Mathewson, Herbert G. Moulton, Scott Turner, Mr. Hoover, John M. Lovejoy, John R. Suman, and Louis S. Cates.

People Make News . . .

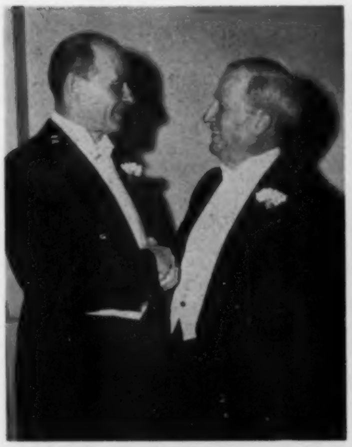
Coal—explicitly, *Export Coal and the American Merchant Marine*—was the topic discussed by Richard L. Bowditch. Mr. Bowditch, who is chairman of the board of C. H. Spragg & Co., Boston, was the principal speaker at the Coal Division luncheon on Tuesday .

ABOVE: J. Roy Gordon, executive vice president of both International Nickel Co. and Canadian Inco, and AIME President Holt listen to John F. Thompson, right. Mr. Thompson, chairman of the board of Inco, was honored recently by his company when a new nickel mine and town were named for him. BELOW: Three keymen among those guiding AIME finances enjoy a chat during the meeting—Andrew Fletcher, St. Joseph Lead Co.; H. DeWitt Smith, Newmont Mining Co.; and Charles R. Dodson, First National City Bank. Both Messrs. Fletcher and Smith are AIME Past-Presidents while Mr. Dodson is currently serving as AIME Treasurer.

. . . At Annual Meetings

John Ray Dunning, head of the School of Engineering at Columbia University in New York, was the speaker at the SME Dinner on Tuesday. Mr. Dunning was introduced by Toastmaster Elmer A. Jones, outgoing President, who also welcomed incoming SME President Stanley D. Michaelson.

TOP BELOW: Petroleum may have been the topic as award winners Carl E. Reistle, Jr., and John Suman, center, confer. Mr. Reistle received the Anthony F. Lucas AIME Gold Medal, while Mr. Suman received the John Fritz Medal, an honor bestowed by the Four Founder Societies. Both men are AIME Past-Presidents. Caught in a reflective mood was Richard J. Charles, right, who received the Rossiter W. Raymond Memorial Award for his paper *Energy-Size Relationships in Comminution*, published in MINING ENGINEERING in January 1957. BELOW: Homestake veterans exchange notes. Donald H. McLaughlin, Homestake president and new AIME Honorary Member, enjoys a remark by his vice president and general manager, Abbott H. Shoemaker, who is this year's Jackling Award Lecturer. His lecture topic—*Deep Mining at Homestake*.



Two spots in the Hotel Statler that truly represented some of the service the Society of Mining Engineers offers to its members were the Preprint Headquarters and the magazine display booth. The inaugural year for SME's Preprint Program proved a huge success and augured well for future expansion. The display booth for MINING ENGINEERING, with its gay decor of mounted covers, showed some of the features of the monthly magazine.

SME Celebrates First Anniversary

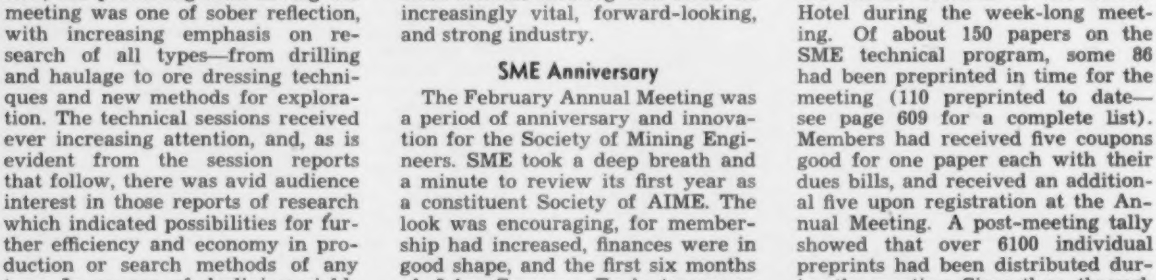
AT a time when economic conditions are making headlines and the future outlook of the minerals industry is clouded by talk of recession, the prevailing tone during the meeting was one of sober reflection, with increasing emphasis on research of all types—from drilling and haulage to ore dressing techniques and new methods for exploration. The technical sessions received ever increasing attention, and, as is evident from the session reports that follow, there was avid audience interest in those reports of research which indicated possibilities for further efficiency and economy in production or search methods of any type. In an era of declining yields and rising costs—for labor, machinery, overhead—new ways must be found to combat the narrowing cost/profit ratio. Thoughtful members of the professional societies are realizing, more than ever, that from the interchange of ideas and technical data at conferences such as the SME Annual Meeting will come an increasingly vital, forward-looking, and strong industry.

SME Anniversary

The February Annual Meeting was a period of anniversary and innovation for the Society of Mining Engineers. SME took a deep breath and a minute to review its first year as a constituent Society of AIME. The look was encouraging, for membership had increased, finances were in good shape, and the first six months of John Cameron Fox's tenure as Secretary of SME saw great strides made in implementing and strengthening the Society under the overall Long-Range Plan of the Institute.

This was a meeting of innovations, too, for SME launched its highly successful Preprint Program and the Preprint headquarters was one of the busiest sections of the Statler Hotel during the week-long meeting. Of about 150 papers on the SME technical program, some 86 had been preprinted in time for the meeting (110 preprinted to date—see page 609 for a complete list). Members had received five coupons good for one paper each with their dues bills, and received an additional five upon registration at the Annual Meeting. A post-meeting tally showed that over 6100 individual preprints had been distributed during the meeting. Since then, through mail and phone orders, a total of over 12,200 have been sent out—an enviable record for an experimental program! Member reactions and

The SME Dinner brought together luminaries from the Society, its Divisions, and AIME. Seen in the picture below, left to right, are: Nathaniel Arbiter and W. B. Stephenson, 1958 and 1957 MBD Chairmen; R. M. Grogan and T. L. Kesler, 1958 and 1957 IndMD Chairmen; F. D. DeVaney, Richards Award winner; Will Mitchell, Jr., 1957 SME Past-President; Grover J. Holt, 1957 AIME President; John Ray Dunning, dinner speaker; and Elmer A. Jones, toastmaster and 1957 SME President. Left to right in the picture on the opposite page are: S. D. Michaelson and J. W. Woomer, 1958 SME President and President-Elect (Mr. Woomer is also 1958 Coal Division Chairman); A. H. Shoemaker, Jackling Lecturer; Allen F. Agnew, Peele Award winner; Clark Wilson and H. C. Weed, 1957 MGGD Chairman and 1958 "new" M&E Division Chairman; C. T. Holland, 1957 Coal Division Chairman; R. J. Charles, Raymond Award winner; and John Cameron Fox, SME Secretary.



general satisfaction with the program takes it out of the pilot-plant stage and plans are now being made for full-scale production.

Annual Dinner

The theme of continuity and growth was much in evidence when outgoing SME President Elmer A. Jones, as toastmaster, welcomed his successor, Stanley D. Michaelson, 1958-1959 SME President, at the Annual Dinner of the Society on Tuesday evening. Guest speaker at the dinner was John Ray Dunning, dean of the School of Engineering, Columbia University, who very kindly substituted on short notice for Leo Wolman, noted economist, who was unable to attend due to illness. Mr. Dunning reiterated one of themes very much on everyone's mind—engineering needs for scientific and technical manpower.

Mining & Exploration

Highlight of the meeting for MGGD was its demiss and rebirth as the Mining and Exploration Division—a new name and new organizational structure under revised By-laws. Continuing a practice started in New Orleans last year, the Division held an all M&E day on Wednesday, with a morning devoted to a technical session for all Division members. The luncheon and business meeting followed the session, at which time presentation of the Jackling Award to Abbot H. Shoemaker took place. Allen Agnew also received the Robert Peele award at the MGGD luncheon. That afternoon Mr. Shoemaker delivered the annual Jackling lecture on the topic—*Deep Mining at Homestake*. On the other three days of the meeting, the technical sessions for Division members were broken into more specialized areas for fields of interest.

Economics

Although the economic activities of the old Mineral Economics Division of the former Mining Branch of AIME now come under the Council of Economics, an all-Institute organization, many of the papers on the two sessions held by the Council were of particular interest to SME members, particularly those dealing with nonferrous metals.

Incoming SME President congratulates outgoing Division Chairmen on a job well done. Left to right are T. L. Kesler, IndMD; Clark Wilson, MGGD (now M&E); President S. D. Michaelson; C. T. Holland, Coal; and W. B. Stephenson, MBD. For these Division officers with their 1958 counterparts, see the pictures below and left.

Minerals Beneficiation

MBD scheduled a full roster of technical sessions, including joint sessions with the SME Industrial Minerals Division and with the Iron and Steel and Extractive Metallurgy Divisions of The Metallurgical Society. The Scotch Breakfast, with its usual rugged breakfast menu, was an all-star hit. The Division luncheon, held on Thursday, honored Robert H. Richards Award recipient Fred D. DeVaney.

Industrial Minerals

One of the guests of honor at the Industrial Minerals Division luncheon on Tuesday was Mrs. Bertha Hardinge. Mrs. Hardinge through a generous bequest has made possible the establishment of an AIME award for achievement in the industrial minerals field which is to be named the Hal Williams Hardinge Award in honor of her late husband, a pioneer in the field. Tom Ware of International Minerals & Chemical Corp. was the principal speaker and a paper based on his talk will be found on page 570. In addition to this luncheon, a full program of technical sessions was scheduled by the Division.

Coal

Seven top-notch technical sessions were on the roster for the Coal Division and an outstanding group of speakers was assembled. The annual Division luncheon and business meeting was held on Tuesday. For further news of the Division, see its inaugural *Newsletter* on page 598 of this issue, with the resume of scholarship activities.

Two outside groups participated in the AIME Annual Meeting this year. The Society of Economic Geologists joined the geologists of the M&E Division in some of their sessions, while the Mining and Metallurgical Society of America held their annual luncheon on Tuesday of the meeting.

Technical Sessions

Coal Division Reports

Bump Symposium—The formal papers included in the *Bump Symposium* represented a full program for the time allowed, with little or no opportunity for questions and discussions from the floor. The papers, however, as presented by the recognized authorities included in the panel provided very comprehensive coverage of the subject and probably constitute the most complete and reliable information available on mine bumps. It is certain that everyone attending the session became better informed on the phenomena of mine

(Continued on next page)

The economists gathered for the annual luncheon of the Council of Economics of AIME. Among those at the head table were, left to right, Frank R. Milliken, Evan Just, A. H. Lindley, Jr., Douglas D. Donald, G. C. Monture, and E. W. Pehrson. The affair was a combination business/social one.

bumps, their occurrence, and what is being done to predict and prevent them. The technical analysis and research studies in progress at the present time under the sponsorship of the Canadian Dept. of Mines and Technical Surveys and the U. S. Bureau of Mines as well as by individuals included in the panel were the source of great interest and are certain to add much to the general information on causes and prevention of bumps. Those papers dealing with the prevention of bumps through the application of specific techniques and methods in mines and areas with past history of frequent and disastrous bump occurrence gave positive evidence that progress is being made in reducing the frequency and severity of bumps in coal mines. There was, however, complete unanimity in the opinion that much fundamental information is yet needed to develop accuracy and dependability into the prediction and prevention of violent pillar failures.— *G. R. Spindler*

Coal Preparation—Four papers were presented, two on the operation of new preparation plants, one where flotation had been added to the fine coal circuit of an existing plant, and another on the unique convertol process for recovering fine coal from coal slurries.

An excellent paper by R. E. Joslin presented operating data on a new plant using two gravity-heavy media separation in the coarse coal section, Deister tables on the fine coal, followed by helpful information on heat-drying coal for the metallurgical market.

Victor Phillips' paper on the Humphrey preparation plant was accompanied by numerous slides which showed the plant from the beginning of construction to the completion. The paper also included valuable operating data on a plant using the Chance sand process for the coarse coal; Deister tables for the fine coals; the Hyslop screen for dewatering coarse coal; and vibrating screens, basket-type centrifuges, and vacuum filters for dewatering the fine coal.

The third paper by M. C. Chang gave valuable data on the addition of a flotation circuit to a fine coal circuit of an existing plant. Lower solids in the circulating water circuit improved the performance of the other equipment in the plant to such an extent that the overall clean coal product was improved beyond their expectations.

S. C. Sun's report of an investigation of the effectiveness of various oils and hydrocarbons to recover fine coal from a coal slurry presented information on various operational conditions necessary for the ultimate recovery and quality of product.— *P. L. Richards*

Fluidized Thermal Drying of Fine Coal—An overflow crowd heard that fluidized thermal drying of fine coal is now a reality. Installations have been made by three equipment manufacturers—Heyl & Patterson Inc., Dorr-Oliver, and Silver Engineering —in both the United States and Canada and range from bituminous coal to lignite. Some operators have reported success in drying —28 mesh coal although it may be necessary to have some coarse coal present in order to prevent balling. Economics of drying fine coal by this method appear very encouraging and undoubtedly many installations will follow.—*D. A. Dahlstrom*

Technical Session—The Wednesday morning session was a general one devoted to practical problems. C. R. Nailler explained how Christopher Coal Co. selects foremen on the basis of the Minnesota multiphase personality inventory and justified the selections on the basis of on-the-job appraisals of the relative merits of all foremen compared with their test scores. The importance of having tests administered by trained personnel and the need of better tests for many mining jobs were developed in the discussion.

Albert M. Keenan and Andrew Allan gave a two-step presentation of the problems of mining a coal seam pitching at 30°. They left most of the group with the conviction that not all of the difficulties of coal mining are found in flat seams—the mountainous terrain posed questions of access to the seam at openings up the dip so all supplies could be lowered underground, and also prevented prospecting by drilling. Friable, dusty coal increased mining difficulties. In the extensive discussion, Thomas Allen, chief coal mine inspector of Colorado, in humorous and pointed comment, emphasized that intelligent and determined management is overcoming the very difficult situations imposed by the region.

C. W. Rountree, Jr., gave an overall picture of the applications of industrial engineering to coal mining, and showed how mining costs had been materially reduced over a period of years by use of the various techniques. Extensive questioning indicated that an increasing number of companies are considering establishment of industrial engineering departments.—*E. M. Spokes*

Coal Technical Session—Four papers were presented at this meeting in which there were 80 in attendance.

The first paper, by C. S. Conrad, described the benefits which can be derived from the use of ac power at the face. The main points covered were the distribution of both high and low voltage and the safety features.

R. J. Grace presented results of a limited research program devoted to the study of the adaptation of a water-cooled grate stoker used in conjunction with a conventional steam boiler for the production of coke.

W. P. Place traced the development of trolley phone communication to present day application of frequency modulated carrier circuits in mining and industry.

The fourth paper, by R. R. Richart, compared the installation and operating costs of an automatic skip hoist vs a belt slope for deep coal seams. The author discussed the electrical control of both systems and analyzed installations and operating costs.—*C. L. Sarff*

Technical Session—Safety features that went into the design and development of the new Ireland mine were described in detail by G. W. McCaa. The most serious safety problem to be considered at the Ireland mine was the control and support of the roof. The immediate roof overlying the Pittsburgh No. 8 coal seam in the Ohio river area is inherently weak, being composed of a layer of draw slate above which

(Continued on page 610)

SME PREPRINTS AVAILABLE

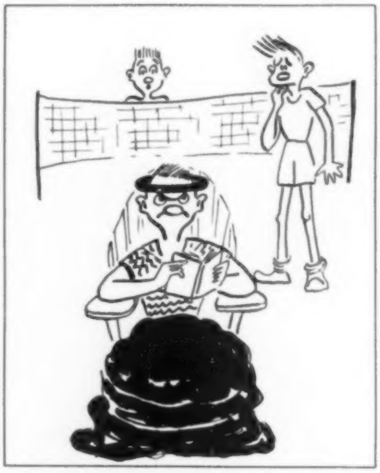
SME Annual Meeting papers (February 17 to 20 in New York) have been preprinted and are still available; see list below. These preprints are available on a coupon basis. The coupon books may be obtained from SME headquarters for $5.00 a book (10 coupons) for members or $10.00 a book for nonmembers. Each coupon entitles the purchaser to one preprint. Mail completed coupons to *Preprints*, Society of Mining Engineers, 29 W. 39th Street, New York 18, NY.

5817A1—The Pima Open Pit and Haulage Facilities by Robert Thurmond.
5817A2—Mining of Magnetite and Martite at Benson Mine by Arthur F. Peterson, Jr., and Wm. P. Bach.
5817A3—Estimating Data for Haulage Trucks—Open Pit Mines by Howard Wilmeth.
5817A4—Problems in Mechanization in Primitive Countries by James V. Thompson.
5817A5—Intrusions and Ore Deposition in New Mexico by Charles Belt, Jr.
5817A6—Some Considerations in Determining the Origin of Ore Deposits of the Mississippi Valley Type by E. L. Ohle.
5817A9—Time Aspects of Geothermometry by R. J. P. Lyon.
5817A10—Ball Mill Performance at Super Critical Speeds by R. T. Hukki.
5817A11—A Study of Different Types of Steel for Grinding Media at Climax by F. Windolph and E. J. Duggan.
5817A12—Single-Stage vs Two-Stage Grinding at Homestake by C. E. Schmidt and F. M. Howell, Jr.
5817A13—Pebble Milling at Faraday Uranium Mines by R. J. Roach.
5817A13a—A Study of Grinding Ball Wear Employing Radioactive Tracers by A. L. Wesner, M. Pobereskin, and J. E. Campbell.
5817A18—Coal Mine Bumps Can be Eliminated by H. E. Mauck.
5817A20—Some Notes on the Principles of Mine Hydrology by H. E. LeGrand.
5817A23—Grouting and Water Control in the Kentucky-Illinois Fluorspar Area by Fred C. Wrobbel.
5817P1—Preplanning Safety in the Uranium Mining Industry by John E. Bailey.
5817P2—Increased Safety, Better Production, Through Use of Communication and Electronic Equipment by Earl A. Berry.
5817P3—Symposium on Safety and Health by James Westfield, John A. Johnson, Henry N. Doyle, and Miles P. Romney.
5817P5—Lineament Tectonics and Some Ore Deposits of the Southwest by Evans B. Mayo.
5817P9—Relation of Magnetic Susceptibility to Composition in Sphalerite and Minerals of the Wolframite Group by E. M. Spokes and D. R. Mitchell.
5817P10—The Metallurgical Story at Inspiration by C. B. Kettering and K. L. Power.
5817P12—Collector Mixtures and Collector Frother Emulsions in Sulfide Flotation by Arvid E. Anderson.
5817P13—Coal Preparation at the Humphrey Mine by Victor Phillips.
5817P14—Application of Mineral Dressing Fundamentals to the Solution of the Fine Coal Problem by M. C. Chang and John Dasher.
5817P16—New Concepts for the Dependable Lifting of Bulk Solids by Bucket Elevator by C. R. Davis.
5817P17—Removal of Heat in Cement Grinding by J. R. Tonry.
5817P18—A Critical Study of Thickening by A. M. Gaudin, M. C. Fuerstenau, and S. R. Mitchell.
5817P19—The Application of a Jig for the Beneficiation of Sand and Gravel by John Meckenstock.
5817P20—The Application of Horizontal-Type Filters to the Metallurgical Industries by W. F. White.
5817P24—Economics Evaluation of an Industrial Mineral Project by J. E. Castle.
5817P25—Current Development in Gravel Beneficiation by W. L. Price.
5817P26—The Use of DSM Screens in a Heavy Media Cyclone Plant by W. R. Van Slyke, James Stukel, and L. D. Keller.
5817P27—Pima Mining Company Concentrator by G. A. Komadina and R. W. Herlund.
5818A1a—The Use of Ammonium Nitrate for Blasting at Mesabi Range Mines by Charles H. Grant.
5818A1b—The Use and Economy of Ammonium Nitrate Fertilizer Grade in the Open Pit Operations of the Anaconda Company in the Western United States and Mexico by A. C. Bigley.
5818A1c—Blasting with Ammonium Nitrate by Lewis J. Patterson.
5818A1d—Blasting with Prilled Ammonium Nitrate Fertilizer by W. M. Chapman.
5818A2a—Conveyor Belts at Miami Copper Co. by Benjamin R. Coil and James B. Fletcher.
5818A2b—Underground Conveyor Experience at Inland's Iron Mines by Howard M. Graff and James R. Gronseth.
5818A3—Raising by Use of a Cage by John C. Wangaard.
5818A4—Lac Tio Ilmenite Deposit by E. O. Dearden.
5818A5—The Titanium Sands of Southern New Jersey by Frank J. Markewicz, Daniel G. Parrillo, and Meredith E. Johnson.
5818A7—Sand Deposits of Titanium Minerals by J. L. Gillson.
5818A7a—Exploration Methods and Evaluation of Sand-Type Deposits by Frank McKinley.
5818A12—Effect of Soil Contamination on Geochemical Prospecting in the Coeur d'Alene District, Idaho by F. C. Canney.
5818A13—Significance of Geochemical Distribution Trends in Soil by D. H. Yardley.
5818A15—Solubility of Some Metal Ethyl Xanthates by P. S. M. van Heteren and P. L. DeBruyn.
5818A16—Activation and Deactivation Studies with Copper on Sphalerite by A. M. Gaudin, G. W. Mao, and D. W. Fuerstenau.
5818A17—Correlation of Contact Angle, Adsorption Density, Zeta Potential, and Flotation Rate by D. W. Fuerstenau and A. M. Gaudin.
5818A18—Experience with the FluoSolids Fine Coal Dryer by M. W. Brandt.
5818A20—The Parry Dryer by R. J. Lofquist and James C. Wright.
5818A21—Effect of Iron Oxide Slime Coatings on Silica Flotation by A. M. Gaudin and M. L. Miaw.
5819A1—Some Legal Problems Encountered in the Acquisition of New Mineral Property by R. E. Driscoll, Jr.
5819A3—Economics of Geologic Exploration by Donald M. Davidson.
5819A4—Valuation of a Mineral Deposit by A. L. Slaughter.
5819A5—Free World Demand and Supply of Chrome Ore by J. M. Warde.
5819A6—Chemical Fuels and Other Organometallic Compounds—Their Impact on the Mineral Industry by Donald Gibbons.
5819A7—Recent Developments in the Allowances for Percentage Depletion by Frank H. Madison.
5819A8—An Exciting Future Ahead with Lead—An Industry Program by R. L. Ziegfeld.
5819A9—Comparison of 2400 and 4160 Volt Distribution Systems for Concentrators by R. M. Wilson.
5819A10—Earthquake Design for Metallurgical Plants by W. B. Hester.
5819A11—Tailings Line Design at Affected by pH by A. A. Wallach.
5819A12—Factors in the Selection of Motors and Speed Reducers for Conveyor Drives by Clark B. Risler.
5819A13—Coal Mine Personnel Selection by C. R. Nailler.
5819A14—Meeting the Challenge of Mining in Thirty Degree Pitching Coal Seams by Albert M. Keenan and Andrew Allan.
5819A15—The Application of Industrial Engineering in Coal Mining by Charles W. Rountree, Jr.
5819A16—New Trends in Uranium Geology by Donald L. Everhart.
5819A18—Commercial Thorium Ores by H. E. Kremers.
5819P2—Dry Magnetic Cobbing Separations by Wm. M. Aubrey.
5819P3—Magnetic Separation in Beneficiation of Mesabi Range Magnetic Taconite by J. E. Forciea, L. G. Hendrickson, and O. E. Palasvirta.
5819P4—Magnetic Separators in the Heavy Media Process by K. E. Merklin.
5819P5—Benefits Which Derive From the Use of A.C. Power Underground by C. S. Conrad.
5819P6—Continuous Coke Production on a Water-Cooled Grate Stoker by R. J. Grace and Jos. D. Doherty.
5819P7—Pioneering Carrier Communication and Control in Mines and Mills by W. Porter Place.
5819P8—A Comparison of Installation and Operating Costs of Automatic Skip Hoisting vs Belt Slope for Deep Coal Seams by R. R. Richart.
5819P9—Underground Movement and Subsidence Over the U. S. Potash Co. Mine, Div. of U. S. Borax and Chemical Corp. by E. H. Miller and F. L. Pierson.
5819P10—Boron—Its Past, Present, and Future by D. S. Dinsmoor and Frank Weishauph.
5819P11—Uses of Standard Ottawa Testing Sands by Paul A. Gerding.
5819P12—Utilization of Pennsylvania Slate for Expanded Aggregate by Frank D. Hoyt.
5819P13—Jackling Lecture—Planning Deep Mining at Homestake by A. H. Shoemaker.
5820A2—Statistical Method of Calculating and Analyzing Ore Reserves by John A. Patterson.
5820A4—Fundamental Studies of Percussion Drilling by Howard L. Hartman.
5820A6—Rapid Field Methods for the Colorimetric Determination of Nickel for Use in Geochemical Prospecting by Harold Bloom.
5820A8—A Nuclear Detector for Beryllium Minerals by T. Cantwell, N. C. Rasmussen, and H. E. Hawkes.
5820A11—FluoSolids Roasting of Sulfides for Recovery of Copper, Iron, and Sulfur by H. Kurushima and R. M. Foley.
5820A12—Beneficiation of Low Grade Iron Ores Involving Direct Reduction by Alex Stewart and H. K. Work.
5820A13—Reduction of High-Grade Port Henry Magnetic Concentrates by Earle C. Smith and D. E. Babcock.
5820A14—Recovery of Iron Ores Containing Titanium, Manganese, Chromium, and Alkali Metal Sulfates by A. G. Oppegaard, O. Moklebust, and G. G. Reed, Jr.
5820A15—Resin-in-Pulp Process at Mines Development Inc. by H. D. Webb, G. F. Richards, and G. T. Bator.
5820A16—Climax Uranium Co.'s Approach to Vanadium Recovery by Solvent Extraction by R. E. Musgrove, E. E. Maurer, and R. E. Fischer.
5820A17—Amine Extraction of Port Radium Leach Liquor by M. E. Grimes.
5820A18—New Solvent Extraction Techniques for Uranium Purification by R. S. Long, J. E. Magner, and D. A. Ellis.
5820A19—Safety Features in the Design and Development of Ireland Mine by Geo. W. McCaa.
5820A20—Auxiliary Ventilation of Continuous Miner Places by R. W. Stahl.
5820A22—Beneficiation of Iron Ores High in Phosphorus and Sulfur by Alex Stewart, G. G. Reed, Jr., and P. Herasymenko.
5820P1—The Bicroft Uranium Mines Operation by J. D. Bryce and J. M. Thompson.
5820P2—Open Pit Mining Operations, Knob Lake, Canada by A. E. Moss.
5820P3—Mining at Eagle-Picher's Esmeralda Unit, Parral, Mexico by R. B. Taylor.
5820P4—The Moa Bay-Port Nickel Project—New U. S. Nickel and Cobalt From Cuban Ores by Forbes K. Wilson.
5820P5—The Trials and Tribulations of Launching a New Airborne Geophysical Method by Hans Lundberg and J. H. Ratcliffe.
5820P6—A Study of the Electrochemistry of Self-Potentials Associated with Sulfide Ore Bodies by Motoaki Sato.
5820P9—Meteorological Influence on Radon Concentration in Drill Holes by Allan B. Tanner.
5820P13—Automatic Weighing and Ratioing of Solids by Thomas L. Mell.
5820P14—Development in Continuous Weighing of Bulk Solids by T. P. Goslin.
5820P15—Hydraulic Solids Flowmetering by E. J. Klein and E. F. Nagle.
5820P16—Gamma Ray Gages in Beneficiation Plants by John R. Riede.
5820P18—Bonding Experiments on Bituminous Coal Mine Roof Strata by E. R. Maize.
5820P19—Roof Bolting in Kentucky Coal Mines by George K. Martin.
5820P20—Handling Air from Conventional Coal Dryers by M. I. Dorfan and Raymond Mancha.

AIME Forum Cruise February 21 to 28, 1958

SEASICKNESS

BERMUDA



TECHNICAL SESSIONS

In order to retain the cultural atmosphere that surrounded the AIME Forum Cruise to Bermuda and Nassau, this account will be presented as a series of tips and admonitions to future cruisers. Under the leadership of Newell Appelton and in the presence of men like Joe Haller and Barney Haffner, there was an aura of intellectual curiosity that should not be destroyed. For the usual aspects, see the illustrations above.

Embarkation: Your wife will pack more bags than you can carry yourself. There are, fortunately, little men on the pier to take your things on board. You don't have to tip them if you aren't worried about the condition or disposition of your luggage.

Seasickness: There are several excellent remedies for so-called *motion* sickness. These are particularly efficient when the ship is in port, somewhat less effective when it is leaving the harbor, and of questionable value when the ship rolls and pitches.

Nomenclature: When you go to the rear of the ship, you are going *aft*. When you are going to the front you're going *forward*, pronounced *ford*. The various levels are called *decks*. None of the passengers will use these terms or understand you if you do.

Bermuda: There are many fine shops in Bermuda. You can purchase and bring back, duty-free, \$200 worth of things per person in your party. It is recommended that you convince your wife that it is illegal to buy or inspect more than \$20

(Continued from page 608)

is a seam of coal 1 to 2 ft thick and then a mixture of shales. The shales weather badly when exposed to the atmosphere. The main roof is limestone. He went on to describe two methods of roof bolting that have proven successful for support of the difficult roof condition encountered. Mr. McCaa cited safety advantages achieved by using ac instead of dc power underground in the face areas. Shaft sinking at the Ireland mine—also described—was patterned after that developed at the company's Eastern Ohio mines. A combination of drilling and blasting is used, and the amount of time men are in the shaft is reduced to a minimum, thereby reducing exposure to the very minimum. After formal presentation, discussion ensued.

R. W. Stahl's paper on auxiliary ventilation of areas using continuous miners invoked considerable interest. Since the introduction of the continuous miner to coal mining has introduced ventilation problems, especially in gassy mines, not heretofore encountered, tests and studies have been made in order to reach a solution. Mr. Stahl described the conditions encountered and the tests conducted. He concluded: 1) ventilation with auxiliary fans seems entirely practicable; 2) tests indicate that a small blower fan, mounted on a continuous mining machine, with conduit to the face, and an exhausting fan in the return, with tubing to the face, would present no difficulties in machine operation; and 3) auxiliary ventilation may permit increasing the spacing of crosscuts, decreasing roof-fall hazards at intersections.

The last paper scheduled for the session was not presented.—*J. B. Benson* and *C. M. Donahue*

Technical Session—The papers presented at this session were by-and-large unrelated; however there was a general theme of safety in the first three papers, those dealing with coal dust count and roof control. The first, second, and fourth speakers utilized notes and the presentations were accompanied by slides. These papers were excellently presented by authors thoroughly acquainted with the subject discussed. The third speaker covered *Roof Bolting in Kentucky Mines*. All speakers average a total time of 25 min each. The number of slides varied from 8 to 14 and very effectively supplemented the text.

There was some discussion of all the papers at the session. The last one especially created a good deal of interest from the audience. The several questions related largely to use of alloy metals in construction of the Microdyne to counteract corrosive effect of gases, and also to application of equipment for recovering dust from sources other than coal dryers.—*H. J. Hager*

Council of Economics of AIME Reports

Mineral Economics Session—The four papers presented ranged from the general to the specific—international marketing and general economic conditions to copper prospects and evaluation of an industrial mineral project. G. E. Greening, the first speaker, tried to make a prognosis of what will happen, with a prediction that production and the economy will recover in the third quarter of the year. He felt that the recession was minor and that there was a tendency to exaggerate seasonal swings

by Art Peterson, Jr.

SHIPBOARD GAMES

FORMAL ATTIRE

DEBARKATION

worth. Better still, tell her that it is illegal to go ashore.

Shipboard Games: In the evenings, the social director will line up some parlor games. You will find that musical chairs is much more fatiguing than it was ten years ago. Energetic single ladies have a tendency to pick old married duffers for their partners in these affairs, so be on guard.

Technical Sessions: You may profit by the excellent technical sessions aboard. Many new theories crop up. As an example, it is possible to ask for aces with the Blackwood Convention and have your partner pass your four no-trump.

Nassau: Here you can, with no trouble, spend what you have left from Bermuda. There is no duty on food and liquor consumed in port. Nassau provides excellent facilities for this pastime.

Formal Attire: If in doubt as to whether to wear a dinner jacket, inquire of your friends and peer into adjoining staterooms as people are dressing. When you have reached a logical conclusion, reverse it. You will be with the majority.

U. S. Customs: Upon your return, customs men will inspect your luggage. The inspector with the largest pile of declarations in his hand also has yours. Most passengers have the same first initial that you have, so allow plenty of time.

Debarkation: Your little man will be glad to carry your bags to the taxi stand. You do not have to tip him. For his trouble, however, it is customary to give him whatever cash you have left after the trip.

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up and down. Touching upon defense spending with a $1 billion forecast for missile spending, Mr. Greening felt that economic conditions in February precluded an effect on taxes.

J. Vuillequez, in his discussion of international marketing, emphasized copper in particular, since the price fluctuations in this commodity have received widespread publicity. Of the five types marketed—concentrate, high grade, blister, fire-refined, and wire bars—the 400,000 tons of refined are most economically important. Of the many prices in the world, he compared the U. S. and those quoted on the London Exchange, and cited the example of the effect of the U. S. custom smelter price upon London market.

Confident of the long-range future of copper, as was Mr. Vuillequez, was Joseph Zimmerman, who stressed the need for a promotional campaign to stimulate the use of copper and to open new channels of consumption. Mr. Zimmerman, in analyzing the prospects for the copper industry, investigated the supply-demand situation, both from a domestic and world view; the role of Government; and those factors that have a bearing on domestic and foreign price, such as mining company policy, production costs, methods of marketing and pricing, and psychological influences of shortages or surpluses.

Switching from sensitive copper to industrial minerals, the last speaker, J. E. Castle, stressed that the same factors—supply and demand, marketing, taxes, competition, and fluctuating prices are just as important as in other business enterprises. Marketing, he felt, was, perhaps, of prime importance, both for an existing project and a contemplated one. He went on to analyze fully the various factors to be considered before venturing into development of a given property.—*P. D. Wilson* and *Evan Just.*

Mineral Economics—Frank H. Madison, mineral tax consultant, Behre Dolbear & Co. Inc., advised mining companies to study recent tax court decisions pertaining to depletion allowances which were explained in *Recent Developments in the Allowances for Percentage Depletion.* He said that in light of these new decisions it is entirely possible that mining companies would be entitled to appreciable rebates and that "to protect the interests of the stockholders in mining companies . . . each mining company should file claims for refund based upon the concept of the courts as set for in the decision quoted in his paper."

The chemical industry is an important customer of the mining industry according to D. R. Gibbons, who evaluates chemical processes for Arthur D. Little Inc. He estimated that in 1957 the chemical industry purchased metals and metallic minerals worth $375 million, and nonmetallic minerals excluding hydrocarbons worth $330 million from the mining industry.

By 1970, Free World peacetime demand for chrome ore for all purposes could grow to 5-million tons, approximately double the 2.4-million tons estimated to have been consumed in 1955. John M. Warde, mineral economist, Union Carbide Ore Co., who projected these estimates in his paper *Chrome Ore Outlook* based them on the assumptions that: 1) stainless steel and chrome alloy consumption will rise, 2) requirements for refractories containing chrome to meet the growing needs of the steel industry will expand, and 3) con-

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Industrial Minerals men turned out in full force for the annual Division luncheon. At the head table, left to right above, are R. B. Ladoo, SME Treasurer; John G. Broughton, secretary-treasurer; Clark Wilson, conveyor of greetings from M&E; SME President Elmer A. Jones; Howard C. Pyle, 1958 AIME President-Elect; Thomas Ware (luncheon speaker), International Minerals & Chemical Corp.; and T. L. Kesler, 1957 Chairman. Below left to right are: R. M. Grogan, 1958 Chairman; Mrs. H. W. Hardinge, who has made possible the establishment of the Hardinge Memorial award; Harold Bannerman, U. S. Bureau of Mines; Col. Gordon Chambers, Foote Minerals Co.; W. B. Stephenson, who brought greetings from MBD; E. O. Kirkendall, AIME Secretary; and J. L. Gillson, E. I. Dupont de Nemours.

sumption of chrome chemicals will increase.

R. L. Ziegfeld, secretary-treasurer, Lead Industries Assn., outlined a vigorous program undertaken some time ago by lead producers to develop new and better uses for lead. Key to the program has been an extensive six-month study by Battelle Memorial Institute to evaluate research needs and steer the efforts to develop new markets for lead as effectively as possible.—*A. Knoerr*

Council of Education of AIME Reports

Mineral Engineering Education—Its Challenge and Its Future—The Sunday afternoon session of the AIME Council of Education was divided into three parts: one for the Society of Mining Engineers, the Society of Petroleum Engineers, and The Metallurgical Society. The SME session featured a panel discussion on the challenges and future of mineral engineering education. Each of the five panel members, in a 10-min address, covered the various aspects of the problem—from the university's point of view, from industry's, the curriculum, and the role of the education committee and its future. G. Ralph Spindler discussed the meaning of mineral engineering and H. V. W. Donohoo covered the mineral engineer's education. D. H. Yardley spoke on the five-year curriculum. Paul C. Henshaw, representing industry, explained the company view, while Milton E. Wadsworth discussed the education committee and its future. The five-year curriculum offers benefits to both the student engineer and the company that hires him. It was pointed out that companies hiring five-year men are paying salaries comparable to those offered M.A. graduates if the M.A. man was a four-year graduate prior to his advanced study. The five-year curriculum offers an advantage in depth as well as one for students with possible deficiencies in certain areas of their education.

All-Institute Evening Session—The principal speaker for the evening was Roger V. Pierce, mining consultant from Salt Lake City. The text of his speech was *The Minerals Engineer and What's Next*. He called attention to progress in the minerals industry by comparing it with progress in other industries such as aircraft, electronics, automotive, and others. Our industry has not kept pace in comparison with these other industries in new developments and new processes. He felt the key to our future depends on the performance of the minerals engineer; therefore, developing and utilizing the full potential of the minerals engineer presents a challenge to both educators and industrialists, and to stay competitive, we must make full use of these men.

After Mr. Pierce's inspiring discussion, the Council of Education held a business meeting so that various problems such as the adoption of Bylaws, the relation of the Council to AIME, and the operating procedures for the Council could be discussed. A set of Bylaws for the Council was adopted so that it now has a certain framework within which to work. The main concern of the Council is the continued effective education of the minerals engineer. Hence, the future efforts of this group will be directed toward accomplishing this end.

Industrials Minerals Division Reports

Mining Hydrology—Mine water problems from theory to remedies were discussed, and in theory many problems are similar in that there is a source, a container, and an outlet. The outlet is the mine, and the problem is to eliminate or control the water at the outlet. Mr. LeGrande indicated the behavior of the hydraulic system in and around a mining operation when the container is pumped. He discussed the effects of various rates of pumping needed to control the water when there is a source nearby, and when it is just a question of emptying the container. The discussion indicated that additional information is needed to amplify the theory. Mr. Wrobbel discussed several methods of control in mines, essentially, cutting off the flow before it reaches the mining area. Grouting of water courses within the mine and sealing intake areas were two methods used with partial success. By partial success he meant reduction in the total pumping load and lowered pumping costs.

The paper on the Wisconsin Zinc-Lead district was a storm casualty and was not presented. It would have discussed theory and observed results of water control.

Mr. Smoke's paper on industrial ceramic materials was of great interest and gave details on new developments in electronic and sound insulators, as well as coating materials. He indicated that the new materials are playing important roles in our industrial development.—*Wilbur T. Stuart.*

General Industrial Minerals—A general range of subjects, both practical and theoretical, were presented at the session, a joint one with MBD. New concepts for dependable lifting of bulk solids by bucket elevator, current developments in gravel beneficiation, and the application of a jig for the beneficiation of sand and gravel were some of the subjects covered which find a more immediate application. These topics were discussed by C. R. Davis, W. L. Price, and John Meckenstock. W. F. White told about application of horizontal-type filters to the metallurgical industries, and W. R. Van Slyke, James Stukel, and L. D. Keller discussed the use of DSM screens in a heavy media cyclone plant. Of a more theoretical nature was the paper on a critical study of thickening by A. M. Gaudin, M. C. Fuerstenau, and S. R. Mitchell.—*J. W. Snavely*

Uranium, Thorium, and Beryllium—Uranium shared the spotlight with thorium and beryllium during the rare and radioactive minerals session. Donald L. Everhart, geologic advisor, Div. of Raw Materials, AEC, discussed *New Trends in Uranium Geology.* In reply to questions, he stressed the fact that in considering processes of uranium concentration, each deposit must be considered individually—generalizations are no longer enough.

Lowell S. Hilpert, geologist, USGS, presented a paper on the geology of the uranium deposits in the Ambrosia Lake-Jackpile area, New Mexico. In addition to describing the geology of the known occurrences, Mr. Hilpert suggested other favorable areas for prospecting. However, there was no stampede toward the door.

Commercial Thorium Ores were discussed by Howard E. Kremers, secretary, Lindsay Chemical Co. The audience was particularly interested in this first adequate description of the massive monazite deposits in South Africa. Dr. Kremers noted that this monazite was probably the first radioactive ore used as a war weapon—because of its high specific gravity, the Bushmen used fragments of it in slingshots. Dr. Kremers answered many questions regarding the various thorium and rare-earth deposits he described. He feels that the use of thorium in atomic energy is still far in the future. Also, even though large quantities of thorium were recovered from the Blind River deposits, there will still be a market for monazite.

Mrs. Hal Williams Hardinge, guest of honor at the Industrial Minerals luncheon, spoke to the group. Mrs. Hardinge has made a gift to AIME for the establishment of an award to be named in honor of her late husband, a pioneer in the mineral industry.

A very lively discussion period followed S. A. Feitler's paper on *Beryllium Raw Material as it Affects the Growth of the Industry.* Mr. Feitler, formerly with the Beryllium Corp. and now with USBM, gave a very comprehensive review of beryl and other beryllium minerals. Most beryl is still recovered by handsorting from pegmatites. It is one of the few minerals for which beneficiation costs cannot compete with handsorting, because most of the deposits are small and scattered and do not warrant the capital expenditure for processing plants. However, in North Carolina, beryl might someday be recovered as a byproduct of the existing spodumene operations. The beryllium raw-materials industry is in a vicious circle. Not enough beryl can be produced from large pegmatites to warrant the search for new uses. And without the stimulus of new uses and larger markets, new techniques will not be found for recovering beryl from presently uneconomic pegmatites and for finding and processing nonberyl sources.—*Pauline Moyd*

General Industrial Minerals—Five papers were presented and some phase of five different commodities was discussed. E. H. Miller and F. L. Pierson reviewed operations at the U. S. Potash Co. mine. Observed measurements of subsidence, both surface and underground, were given. Subsidence has been incident to the removal of about 90 pct of the pillars left by the room-and-pillar method of mining.

A story of boron by F. H. Dinsmoor and F. H. Weishaupl traced the history, present usages, mineralogy, and geology. Mr. Weishaupl suggested that the recent interest in boron in specialty products may be a preliminary to much wider application and increased consumption.

H. R. Tonry described various procedures by which heat, generated in the grinding process, may be removed. A proposed method of cooling the mill charge was illustrated, with calculations and typical results.

P. A. Gerding gave the specifications of three standard testing sands, ASTM C-190, ASTM C-109, and AFS Standard Sand, all of which call for sand coming from Ottawa. Mr. Gerding discussed the techniques of producing these sands and commented on their uses.

F. D. Hoyd pointed out that a relatively new industry has developed from the use of waste slate in the Lehigh-Northampton slate district of Pennsylvania. By grinding and firing the slate an acceptable expanded aggregate is produced and sold under the trade name of Exalite.

After each paper the speaker received numerous questions from the audience.—*R. S. Shrode*

Minerals Beneficiation Division Reports

Crushing and Grinding—Five papers on grinding were presented at the opening session on Monday morning, which was attended by 111 members. Interest was keen and in the discussion after each paper six or seven members asked questions or commented on the papers. All the authors had illustrated slides, with the exception of Professor Hukki who was unable to be present in person and his paper was well reviewed by Nat Arbiter.

The Climax paper on alloy balls tested at their mine was presented ably by Frank Windolph. He pointed out that the grinding efficiencies of balls should be studied as well as their wear qualities. They found 6 pct more capacity with softer grinding balls.

F. M. Howell, Jr., gave the Homestake paper comparing one and two-stage grinding studies at their mill. They concluded that "a 10 pct saving in mill operating costs" can be effected "through the use of two-stage grinding units as compared to single-stage units. For installations of high daily tonnage capacity and prolonged mine life, etc., two-stage milling unit will justify its higher capital cost."

Dick Roach presented the paper on the application of sized run of mine ore as grinding media to secondary grinding in the Faraday mill. This grinding process has been both astonishingly simple and most economic. The uranium leach plant has not only saved the cost of ball mill steel, but also on acid and chlorate cost. The total saving amounted to

16¢ per ton of ore milled and increased the capacity of the plant by 3.5 pct.

The use of radioactive tracers to study the wear of various alloy balls in a grinding mill was the subject of a paper by the Battelle Memorial Institute and presented by A. L. Wesner. The balls were sorted and identified by this new technique and many interesting tables were shown on the wear rates of alloy balls used in grinding.

Professor Hukki's paper on laboratory mills operating up to 2000 pct of critical speed was presented by Nat Arbiter. The paper presented many new ideas developed by this study.—*B. S. Crocker*

Concentration—An audience of about 75 listened to five very interesting papers at the session on concentration. Papers covering both the practical and theoretical phases of concentration were presented, and in addition one paper described the Pima mill. Another paper gave a very complete account of the Inspiration story.

Fred D. DeVaney received the Robert H. Richards Award for his contributions in beneficiation, particularly taconite. He spoke at MBD's luncheon on Thursday.

A paper on the magnetic susceptibility of various minerals delivered by E. M. Spokes drew active discussion from the audience, and further information along this subject would, no doubt, be of particular interest.

A somewhat unique idea in reagents was presented by Arvid Anderson in his paper on xanthate and frother emulsions and was enthusiastically received by the audience.

Two authors were unable to reach the meeting because of the storm. Komadina's description of Pima was very ably given by Earl Herkenhoff, and John T. Sherman gave a most interesting impromptu talk covering the features in R. H. Kennedy's paper on trends in uranium milling. —*R. H. Lowe*

Theory of Concentration Processes—This session was a cooperative effort between the MBD Planning Committee and the MBD Education Committee. Although the point of view was one of theory, several practical implications resulted from the session.

A. M. Gaudin, in his discussion of effect of iron oxide slime coatings on silica formations, presented a variety of interesting results from a systematic study, and suggested the main interference of slimes is to provide a mechanical barrier for particle bubble attachment.

In a discussion of the solubility of methyl ethyl xanthates, Philip L. de Bruyn gave a description of special interest, since the solubility product of xanthates limits the available xanthate in solution. The practical implications involve the economic use of reagents of flotation beyond which valuable reagents are lost in precipitated form.

Douglas W. Fuerstenau presented an interesting paper in which he correlated a variety of measurements related with the surface chemistry of minerals. He showed a distinct correlation between contact angle, adsorption density, zeta potential, and the flotation rate.

Dr. Fuerstenau presented a second paper on activation and deactivation studies of copper on sphalerite which aroused appreciable interest. Conditions providing optimum activation and deactivation of sphalerite with copper were presented. Nathaniel Arbiter pointed out that the actual processes are very complicated and that the real value of a fundamental study of this kind is that it takes the processes apart and contributes to a basic understanding of the individual steps. M. E. Wadsworth, in a paper on mechanism of flocculant adsorption on clay minerals, pointed out the role of the carboxylic acid-type flocculants in replacing waters of hydration on the surface of clay minerals.

The session in general was very successful; much discussion was aroused; and valuable comments were made as a result of the discussion. The sponsors of the session were very pleased with the 95 in attendance.—*Milton E. Wadsworth*

Mill Design—In general the papers presented and the ensuing discus-

A major social event of Annual Meetings is MBD's Scotch Breakfast, and shown in Newsletter cartoon technique are three of the Division's leading figures: W. B. Stephenson, Nathaniel Arbiter, and Rush Spedden. When MBD changes officers they don't waste any time. W. B. Stephenson, 1957 Chairman, vacates the rostrum in favor of Nathaniel Arbiter, new Division Chairman. Interested onlookers are Augustus B. Kinzel, 1958 AIME President, and S. D. Michaelson, 1958 SME President.

February 1958 was "off with the old, on with the new" for miners, geologists, geophysicists, and geochemists as the "new" Mining and Exploration Division was officially erected on the foundations of the former Mining, Geology, and Geophysics Division. Left, at the Division luncheon J. M. Ehrhorn, member of the M&E Executive Committee and publications chairman of old MGGD, presents the Robert Peele Award to Allen F. Agnew for his contribution to the technical literature in the field of geology. Shown on the right are H. C. Weed, new M&E chairman, and R. J. Lacy, Division vice chairman for programs.

sion of each tended to be specific in nature and several continuing problems were emphasized.

R. M. Wilson, in his discussion of voltage systems for concentrators, pointed out that the deciding factor in choice of system was the length of cable run. In answer to a question from the floor, he reported that new insulating materials have made 4160-v circuits as safe as 2400. He also emphasized that the grounding system he had described was not intended to replace equipment grounding and pains must be taken to ground all machinery properly.

Walter Hester gave a comprehensive description, first, of areas in which earthquake movements frequently take place, and then went on to discuss various ways of designing plants to withstand certain intensities of such movements. Generally, buildings are not designed to withstand the maximum intensity but are planned for multiple shocks within a code. Tailings dams are particularly vulnerable but a well point system back from the face of the dam can be used to dry it out and make it safer.

Pilot plant work done to determine the proper slope for the main tailings line at San Manuel was described by A. A. Wallach, who showed how the effect of a rise in pH beyond a certain point affected the flow of materials. In answer to questions on the direct relation of physical condition of the ore to its viscosity and whether it could be expressed in terms of a degree of flocculation, he replied in the affirmative and stressed the need for further information along these lines. Dick Vincent, reporting on Asarco's Silver Bell operation, pointed out that, in some areas of the pit where there was a high clay content, the lines would fill and plug even at 37 pct solids and relatively

(Continued on page 626)

Mining & Exploration Division Reports

Some Economic Considerations in Exploration Geology—Four related papers—which considered legal, business, and geologic problems involved in choosing and acquiring mineral property as well as methods and costs of evaluating and exploring the property—were presented. The final paper discussed operating costs and methods of estimating actual dollar value of a property to a company after all costs and taxes.

In his paper on legal problems of mineral property acquisition, R. E. Driscoll emphasized early cooperation of attorney and geologist to solve ownership problems and adverse claims at a point in the exploration sequence before a high discovered value made solution difficult and costly.

In acquiring mineral property, M. W. Cox pointed out, with examples, the importance of acquiring property quickly on a basis which gives time (at not too great a cost) for carrying out the necessary steps of geologic evaluation and preparation for production. At the same time there needs to be the privilege of closing out at any stage without serious financial obligation, other than what has already been spent.

The cost of modern geologic exploration was discussed in detail by D. M. Davidson who urged that exploration be planned and carried out in stages. Each successive stage might involve methods of increasing detail and cost, but the possibility of evaluation and possible close-out would exist at the end of each stage.

The methods of evaluation of the cash potential of a mineral deposit toward profit or dividend payment were discussed fully by A. L. Slaughter. Type examples were worked out to show procedure.

The authors are to be complimented for an excellent practical presentation of the economic problems of property acquisition, exploration, and evaluation— *James O. Harder*

Open Pit Mining—The session started with a paper on the Pima open pit mine haulage facilities by R. E. Thurmond, mine superintendent. Pima is the first copper producer to include the use of a hoist and skip system for bringing waste rock and ore out of the pit. The orebody, which lies below approximately 200 ft of alluvium and an additional 50 ft of barren rock, required the removal of 9,000,000 cu yd of waste material prior to ore production.

A. F. Peterson, Jr., assistant manager, described the problems and answers for mining magnetite and martite at the Benson Mine of Jones & Laughlin Steel Corp. Factors which present distinct problems are: 1) the nature of the mineral occurrence, 2) the shape of the orebody, 3) the operating schedule, and 4) the climate.

Kennecott Copper Corp.'s efforts to establish estimating data for haulage trucks at open pit mines of the Chino Mines Div. was presented by Howard A. Wilmeth. The objectives of the program were to develop unit costs for estimating future truck haulage costs for any haulage layout, to develop a method for estimating travel time for any haulage layout, and to develop standard yardsticks of performance.

Problems in mechanization in primitive countries by James V. Thompson, Kaiser Engineers, was not presented due to the absence of the author who was delayed by the heavy snow storm. The paper presents the problems which the author encountered when assigned the problem of recommending ways and

(Continued on page 627)

Pacific Southwest Mineral Industry Conference Is Attended by Mining Men from Seven States

Almost 400 mining men from seven western states converged on San Francisco to participate in the 1958 Pacific Southwest Mineral Industry Conference on March 27 to 29. The conference was sponsored by the AIME San Francisco Section, and co-sponsored by the Reno, Las Vegas, and Southern California Sections.

The program, under the chairmanship of J. K. Brooke, included two days of technical sessions and a field trip to Sausalito to inspect the U.S. Army Engineers' two-acre working model of San Francisco Bay. Almost 40 papers, covering the mining, processing, and marketing of industrial minerals found in the west, were presented at the technical sessions.

Fred Lohse was general chairman for the conference. Working with him were K. R. Wilson, chairman, general arrangements; W. Watson, chairman, registration; Bud Duling, chairman, space and properties; and Mrs. E. M. Barker, chairman, ladies' activities.

Roger V. Pierce, Vice President and Director of AIME, was the guest of honor at the opening session. Mr. Pierce characterized the current period of surpluses and depressed prices as a kind of *coffee break* for the domestic mining industry. But he stressed that finding vital minerals in the future is going to require more knowledge and more research than ever; as a consequence mining must attract its share of bright students.

At the opening luncheon the guest speaker, DeWitt Nelson, California state director of natural resources, whose topic was *The Importance of the Minerals Industry*, expressed the opinion that a tariff or excise tax "seems to be about the only solution" to our sick mining industry. But, he said, we should set any levy so as not to eliminate foreign exports and hurt friendly foreign nations.

Mr. Nelson also expressed the opinion that "one of the factors contributing to the present level of unemployment is the low domestic price of gold."

Technical Sessions

The technical sessions on the opening day of the conference were separated into two divisions, Geology and Industrial Minerals. Nine papers were presented at the Geology Division's morning and afternoon sessions, and eight at the Industrial Minerals Division's two sessions.

Richard M. Foose, chairman of the Dept. of Earth Sciences at Stanford Research Inst., Menlo Park, Calif., one of the speakers at the Industrial Minerals Division's Thursday morning session, made the point that vast new reserves of industrial minerals, not simply metals, will be needed to take care of growth demands.

In his talk, *Industrial Mineral Resources of the Western States*, Dr. Foose gave examples to prove that industrial minerals make up a far bigger business and more important part of the economy than most people realize.

An unscheduled addition to the technical papers presented on the opening day was a talk by Gerald Johnson, test division leader of the University of California Radiation Laboratory, Livermore, Calif.

His speech, *Underground Nuclear Explosions—Potential Use in Mining*, was made possible by the recent declassification of some Nevada test data. Dr. Johnson directed underground nuclear explosions which took place last year.

Friday's technical sessions were also separated into two divisions, one on Extractive Metallurgy and the other a continuation of Thursday's sessions on Industrial Minerals. Five technical papers were presented at the morning sessions of each division, and four at each afternoon session.

Social Events

Headquarters hotel for the conference was the St. Francis, and all business meetings and functions, as well as the social events, took place there. A suite was also reserved for members' wives, where a coffee hour was held for them on Thursday morning.

The social events of the conference were well planned and well attended. They included the opening day's welcoming luncheon, at which DeWitt Nelson spoke, and a general luncheon on Friday, when Harvey O. Banks, California Dept. of Water Resources, was the principal speaker. His subject was *The California Water Plan*. For speakers of the day and the program committee, there were breakfast meetings on Thursday and Friday.

A cocktail party on Thursday and a dinner-dance on Friday were attended by both members and their wives. The dinner-dance, for which Rod McCauley provided the music, was a substitute this year for the San Francisco Section's annual party with the Ladies' Auxiliary.

For members' wives attending the conference, there was also a full program of daytime social events. Activities for the ladies started Thursday with a visit to the Japanese Tea Garden in Golden Gate Park, followed by luncheon at the Cliff House, and a sightseeing tour. On Friday the ladies visited Fisherman's Wharf and enjoyed a cruise on San Francisco Bay. Ladies' activities were under the direction of Mrs. E. M. Barker, chairman.

Utah Governor Clyde, Howard C. Pyle to Talk At Rocky Mt. Meeting

Governor George D. Clyde of Utah and Howard C. Pyle, AIME President-Elect and president of the Monterey Oil Co., head the list of speakers for the 5th Annual Rocky Mountain Minerals Conference. This conference will be held in Salt Lake City September 17, 18, and 19 at the Newhouse Hotel.

In outlining plans for the meeting, A. J. Thuli, Jr., general chairman, reported that the committee is looking forward to over 500 delegates and is planning an outstanding list of technical sessions. "With problems currently facing mining, this year's conference will be vital to everyone in the industry," Mr. Thuli said.

The program committee is hard at work planning the technical sessions, and among those planned are special ones devoted to current mining, metallurgical, and petroleum engineering problems. The sessions will cover minerals beneficiation, extractive metallurgy, iron and steel, mining, geology, industrial minerals, petroleum, and coal. Members of all three AIME societies—The Society of Mining Engineers, Society of Petroleum Engineers, and The Metallurgical Society—will find papers of interest.

Governor Clyde will address the welcoming luncheon on the opening day, September 17. Mr. Pyle will speak at the Minerals Luncheon on September 18. The conference will end Friday night, September 19, with a dinner-dance, and the schedule has been so arranged that those wishing to attend the American Mining Congress in San Francisco the following week will have ample travel time. Hotel and motel space, transportation, women's events, and social affairs are all being arranged by the Conference Committee.

Central Appalachian Section, Coal Division Plan Joint June Meeting

AIME Central Appalachian Section and the SME Coal Division will hold a joint meeting at the Phoenix Hotel, Lexington, Ky., on June 13 and 14. This is also the annual spring meeting for the Section.

Planned for the technical program are concurrent separate sessions for the fuels and nonfuels interests. In addition to papers of interest to SME members of the Coal Division, topics covered will be of interest particularly to geologists and engineers in the mining industry. For program details, see the Coal Division News, p. 598.

AIME NEWS

Changes in AIME Bylaw And Rules Proposed

The following changes in the AIME Bylaws and Rules have been proposed:

Bylaws

ARTICLE I, **Section 2b4**: Change "Mining, Geology, and Geophysics Division" to "Mining and Exploration Division."

ARTICLE I, **Section 4**: Add **e**—No Local Section may be organized in a foreign country where there exists a recognized national engineering society in the mineral industry field, without the written consent of the governing body of such society.

ARTICLE V, **Section 6**: Change name of committee to "Local Section Affairs Committee" and change **b** to read—The Board of Directors shall appoint the Chairman on recommendation of the President.

Sections 7, 8: Renumber 8, 9.

Add new **Section 7**: Student Chapter Affairs Committee.

a. *Formation of Committee.* The committee shall consist of three members, one from each of the three AIME constituent Societies, appointed by the Board of Directors on recommendation of the President.

b. *Presiding Officer.* The Board of Directors shall appoint the Chairman on recommendation of the President.

Rules

Rule 1, ARTICLE III, **Section 4**: The following Rule was deleted by the Board of Directors, Feb. 16, 1958—**Section 4.** *Disbursement of AIME Funds.*

Rule 1. *Payments—Current Expense & Payroll.* The Treasurer may at any time place funds of the Institute, not exceeding $10,000, at the disposal of the Secretary's office for the purpose of paying the current expenses of the Institute and may also establish a payroll account. Such funds shall be deposited in the name of the Institute and paid out by checks signed by any two of the following:

a. The Secretary
b. Assistant Secretary
c. Assistant Treasurer
d. Such other employe of the Institute as the Board of Directors shall from time to time designate.

Delete *Rule: ARTICLE V*, **Section 7**, Rule 1c.

Overseas Travel Grants

The National Science Foundation is authorized to provide a limited number of travel grants for the purpose of assisting qualified scientists who wish to attend certain conferences, congresses, and other meetings of scientists held abroad which are concerned with research in the sciences. Decisions will be made by the Foundation concerning specific meetings for which travel support can be extended.

Physical scientists, mathematicians, and engineers who wish support to attend international meetings concerned with subjects in the *physical sciences* should submit application forms for financial assistance prior to June 30 for travel between October 1 and March 31, and prior to December 31 for travel to be performed between April 1 and September 30. Requests for application forms should be addressed to the Assistant Director for Mathematical, Physical, and Engineering Sciences, National Science Foundation, Washington 25, D.C.

1958 Nuclear Congress Preprints Available

A complete stock of preprints for the Nuclear Engineering and Science Conference, and the proceedings of the Hot Laboratories and Equipment Conference from the 1958 Nuclear Congress are still available. Publication of the transactions of this congress in one volume is not planned.

The American Inst. of Chemical Engineers, 25 W. 45th St., New York 36, N. Y., can supply a complete list of titles of the preprints. Price of the preprints is 50¢ per copy. The proceedings of the Hot Laboratories and Equipment Conference sells for $10 per bound volume.

Three Annual Symposia To Have Tri-Sponsors

In past years, the School of Mines and Metallurgy and the Center for Continuation Study at the University of Minnesota have sponsored during the year symposia on drilling and blasting, exploration drilling, and rock mechanics. It has now been announced that in the future the symposia will be broadened to include sponsorship by the Dept. of Mining Engineering at the Colorado School of Mines, the Pennsylvania State University, and the University of Minnesota.

The future symposia will cover the three subjects of exploration drilling, production drilling and blasting, and rock mechanics. It is hoped that better geographical representation, both in papers and attendance, will result in wider dissemination of the new developments and concepts in the mineral industry.

As now planned, the future meetings will be based upon the following schedule: *Drilling and Blasting*, University of Minnesota, 1958; *Exploration Drilling*, Pennsylvania State University, 1959; *Rock Mechanics*, Colorado School of Mines, 1959; *Drilling and Blasting*, Colorado School of Mines, 1960; *Exploration Drilling*, University of Minnesota, 1961; *Rock Mechanics*, Pennsylvania State University, 1961; *Drilling and Blasting*, Pennsylvania State University, 1962; *Exploration Drilling*, Colorado School of Mines; 1963; and *Rock Mechanics*, University of Minnesota, 1963.

Plans for Stope Fill Symposium Completed

Plans for a Symposium on Hydraulic Stope Fill, to be held at the Montana School Mines, Butte, on May 9 and 10, are now complete. Technical sessions will feature the presentation of 11 papers, and there will be two field trips. The lighter side of the program will be covered by a luncheon and banquet.

The symposium, which will take place on the School of Mines campus, is sponsored by the Dept. of Mining Engineering of the school, actively assisted by AIME Montana Section, Mining Assn. of Montana, The Anaconda Co., Montana Soc. of Engineers, and the Alumni of Montana School of Mines.

A considerable portion of the papers presented at the symposium will deal with the theoretical and practical aspects of handling slurries in pipelines, sand and hydraulic filling. Papers by the following will be presented: Fred L. Smith, Donald L. Cenis, R. T. Dottery, W. B. Stephenson, C. N. Kravig, H. F. Beattie, John M. Suttie, J. P. Norrie and H. L. Henry, H. A. Wendel, Rollin Farmin, and George L. Wilhelm.

The papers, with time for discussion, will take all day Friday, and Saturday morning. A lunch for registrants will be held at the Montana School of Mines on Friday, and a banquet sponsored by the AIME Montana Section, Mining Assn. of Montana, Montana Soc. of Engineers, and Montana School of Mines Alumni, is scheduled for that evening. E. I. Renouard, Jr., will be the principal speaker at the banquet.

On Saturday afternoon field trips have been arranged so that registrants can visit the Lexington Fire Fill Plant or the Berkeley Pit, both of The Anaconda Co.

Rocky Mountain Coal

The Rocky Mountain Coal Mining Institute will hold its 54th regular meeting June 29 to July 2. Headquarters will be the Hotel Colorado in Glenwood Springs, Colo.

Among the subjects to be covered on the technical program are safety and safety in Colorado coal mines, and training maintenance personnel. On the operating side, papers will be presented on features of an all-ac mine, belt idler design with reference to the Perma-Seal idler, and purchasing. The development of a mine—Ireland—will be traced. From a board view, the world trade in coal will be discussed. One of the speakers will be M. J. Ankeny of the U. S. Bureau of Mines, and there will be a manufacturers' hour.

In a lighter vein, there will be opportunities for golf, fishing, numerous social events, and special plans for ladies and children attending.

General chairman for the meeting is Charles M. Schloss, and his committee chairmen are: R. R. Williams, Jr., program; M. Vern Woodhead and D. F. McElhattan, finance; Stanley C. Shubart, registration; George A. Ward, golf; Clyde E. Osborn, fishing; and Mrs. R. M. von Storch, ladies and children. For election of officers John B. Hughes is chairman of the nominating committee. Chairman of auditing is Ray Woodward.

May Joint AIME-ASM Meetings To Be Held In Los Angeles

Two conferences, one on high temperature materials and their resources, sponsored by AIME, the other on molybdenum fabrication, sponsored by the Southern California Chapter ASM, will be held jointly on May 5 through 8 at the Ambassador Hotel in Los Angeles.

Special events at the conferences include a luncheon on May 5 at which J. W. Vanderwilt, president of the Colorado School of Mines, will be the guest speaker. Dr. Vanderwilt's topic is *The Free World Resources and Economics of High Temperature Metals.*

N. J. Grant of the Massachusetts Inst. of Technology will speak at a banquet the same evening. *A Metallurgical and Philosophical Tour of Russia* is his topic.

Other special events of the conferences include a May 6 luncheon at which G. N. Gianinni, president, Gianinni Research Laboratory, will speak on *High Temperature Sources in Research* and a May 7 luncheon at which Brigadier General M. C. Demler, USAF, Deputy Commander, Research and Development, Air Research and Development Command, will give a talk, subject of which has not been announced.

Thirty-six papers will be presented at the ten conference sessions. The High Temperature Materials Conference, which takes place on May 5 and 6, will include a metals and mining joint session on Monday, May 5.

Speakers at this session, and their topics, include: R. M. Foose, Stanford Research Inst., *Geology and Resources of Minerals of the High Temperature Metals* and L. Ynetema, Stanford Research Inst., *The Refractory Metals Tungsten, Molybdenum, Columbium, and Nickel.*

Also on Monday, there will be a session devoted to the geological relationships of high temperature metals. Speakers and their topics are: Michael Fleischer, USGS, *Geochemistry of Rhenium;* John K. Gustafson, M. A. Hanna Co., *The Riddle Nickel Project: Oregon*; D. E. Garrett and L. G. Carpenter, American Potash and Chemical Co., *Geology of the Searles Lake Deposits with Special Reference to Tungsten;* Stewart Wallace, Climax Molybdenum Co., *Molybdenum;* and a staff member, USGS, *Tungsten.*

A luncheon-panel discussion on Thursday, May 8, will be a feature of the ASM Molybdenum Fabrication Conference which takes place on May, 7 and 8. *Industry Requirements* is the subject of the panel discussion, and the chairman will be A. V. Levy, Marquardt Aircraft Co.

Group to Study Impact Of Energy on Society

Energy and Its Impact on Society is the general theme of the Second Energy Resources Conference to be held in Denver, October 15 through 17, at the Brown Palace Hotel. The conference is sponsored by the Natural Resources Council of the Denver Chamber of Commerce.

The discussions will be on coal, oil, oil-shale, nuclear, solar resources, and the new super-performance fuels. This year's conference will also venture into a new field of energy—*foods from the sea.*

Around the Sections

Wallace Woolf of AIME Named Inland Empire Engineer of the Year

Wallace G. Woolf, vice president in charge of the Kellogg operations of The Bunker Hill Co., has been named Engineer of the Year of the Inland Empire—the mining region of eastern Washington and the Idaho panhandle.

Mr. Woolf, who was nominated for the award by the Columbia Section of AIME, was one of a group of five candidates sponsored by various Inland Empire chapters of national engineering societies. The award, made annually by the Washington Soc. of Professional Engineers, was presented at a banquet held in Spokane on February 21.

Norman J. Sather, Bunker Hill superintendent of concentration, received the award for Mr. Woolf, who was unable to attend the banquet because he was in New York for the AIME Annual Meeting.

The Columbia Section selected Mr. Woolf as its candidate for the award because of his outstanding contributions to the field of metallurgy, his community work with such organizations as the Boy Scouts of America, and "the personal growth he has shown in advancing from research metallurgist to vice president of the nation's second largest domestic lead producing company."

A 1912 graduate of the University of Utah School of Mines, Mr. Woolf developed and refined techniques for removing mineral values from complex ores and directed pioneer work in the selective flotation process of milling which is now the standard method of treating ore.

W. G. WOOLF

Probably his most outstanding achievement was research work done at Bunker Hill, leading to the development of *four-nine* zinc—that is, zinc 99.99+ pct pure.

Mr. Woolf is a past-chairman of the AIME Columbia Section which nominated him, as well as a member of the Mining and Metallurgical Soc. of America and a director and vice president of the Northwest Mining Assn.

• The **Spokane Subsection,** Columbia Section, featured a double-barreled program at the January 30 meeting at the Coeur d'Alene Hotel. A. F. Wynn, Sunshine Mining Co., discussed *Oil Development in Washington*, describing the general geological picture of the state with regard to petroleum possibilities. He presented an electric log of the Sunshine Tanner—Medina No. 1 at Ocean City, the first commercial oil well in the state. The second part of the program featured E. G. Oman, Western Machinery Co., who presented a film, *The Longyear Wire-Line Core Barrel*.

• The January meeting of the **Reno Subsection,** Nevada Section, was a joint business-program one. Guest speaker was Fred Lohse of Kaiser Aluminum and Chemical Corp. who outlined plans for the 1958 Southwest Mineral Industry Conference held in San Francisco on March 27 to 29. The first conference was held in 1957 in Reno. New Subsection officers, installed at the meeting, are: Edmond F. Lawrence, chairman; Milton Steinheimer, vice chairman; and John Kenneth Jones, secretary-treasurer.

At the Subsection meeting on February 14 held at the offices of Cartographers Inc., Dewey S. Harwood of that firm discussed the application of photogrammetric survey to mine problems, geology, and highway engineering. The use of aerial photographs for measuring contract work in open pit mining operations was described. Mr. Harwood also demonstrated the use of both the Balplex and Kelsh plotters in making topographic maps from aerial photographs. At the meeting, a joint one with Nevada Geological Survey, Vern Cartwright, Cartwright and Co., Sacramento, Calif., exhibited the new Zeiss RMK-15 camera and answered questions on aerial photography and its application.

• E. C. Babson, AIME Vice President, was the featured speaker at the January 17 meeting of the **Oregon Section** held at Burns Restaurant. Mr. Babson, manager of the Canadian Div., Union Oil Co. of California, Calgary, Albe., Canada, discussed *Canadian Oil Fields and What We Do With Them*.

At the February 21 meeting, Section members heard Hollis Dole, director of the State of Oregon Dept. of Geology and Mineral Industries. He discussed gold mining.

• The **Boston Section** held the annual Richards' Night on March 3 at the MIT Faculty Club. The annual event is in honor of Professor Richards and an outstanding figure in the mineral engineering field is the guest speaker. This year S. R. B. Cooke, head of the School of Mines and Metallurgy at the University of Minnesota, spoke on *Problems of the Mesabi Range*. Dr. Cooke, whose work has been in the fields of saline flotation, ore microscopy, and iron ore beneficiation, showed, with the use of slides, the development of the Mesabi Range to its present day position. He emphasized some of the problems that are now encountered in the working of this deposit.

• R. J. Lund, assistant technical director, Battelle Memorial Institute, was the guest speaker at the February 13 meeting of the **Cleveland Section** in the Carter Hotel. Dr. Lund, who assists in guiding Battelle's work in advising clients on problems concerning technical economics, spoke on *Some Patterns and Problems in Future Availability and Use of Metals*. An authority on metal and mineral economics and area development, he was formerly associated with the U. S. Bureau of Mines and was an editor of *Mining Congress Journal*. His talk was preceded by dinner and cocktails.

• Gordon R. Parker, president of the AIME Anderson-Carlisle Society at Montana School of Mines, was guest speaker at the monthly meeting of the **Montana Section** on March 26 at the Physics Auditorium, Montana School of Mines. Mr. Parker, a native of South Africa, discussed *Uranium and South Africa*. He is also general chairman of *E Day* activities on May 15 and 16 at the School. On these days, an open house is held and its purpose is to acquaint the people of Montana with the facilities, equipment, and types

of education Montana School of Mines has to offer. The activities are primarily a student responsibility.

• The March 14 meeting of the **St. Louis Section** was held at the York Hotel. Guest speaker was W. L. Fabianic, vice president of Laclede Christy Co. and director of research, Refractories Div., H. K. Porter Co. Mr. Fabianic spoke about various types of cermets, and described some of the physical and chemical characteristics of them as well as their present and potential uses.

On March 27 the Section held a joint meeting with the Engineers Club of St. Louis. John S. Brown, chief geologist of St. Joseph Lead Co., spoke on *Iron in Missouri*.

• The recently formed **Knoxville Area Subsection** of the Southeast Section held a dinner meeting on April 11 at Holston Hills Country Club, Knoxville, Tenn. Several meetings have already been held, at one of which the following officers were elected: Deane F. Kent, chairman; M. J. Langley, vice chairman; Frank Waddock, secretary-treasurer; and R. T. Wilson, membership chairman.

• The **Yavapai Subsection**, Arizona Section, held its monthly cocktail-dinner meeting on March 4. Entertainment feature of the evening was the showing of a film, *Dawn's Early Light*, prepared by the Westinghouse Electric Corp.

• The **Ajo Subsection,** Arizona Section, met on March 13 at the Copper Coffee Shop, Ajo. Jacques B. Wertz, senior geologist, Kennecott Copper Corp., was the speaker for the evening. His topic was exploration methods in the Belgian Congo, and his experiences there. He illustrated the talk with charts and slides. The business of the meeting included appointing a nominating committee consisting of Mr. Briggs, chairman; W. Ç. Hunter, and Mr. Sullivan, to nominate Subsection officers for next year. Prior to the dinner meeting, the members enjoyed a cocktail hour at the home of F. R. Rickard.

• The spring meeting of the **Black Hills Section** was held on March 20 in Rapid City, S. D. Speaker of the evening was Eugene F. Landt of the Rocky Mountain Forest and Range Experiment Station, Rapid City Research Center, U.S. Forest Service. His talk on *Economics of Wood Products in the Black Hills* called attention to the fact that the greater part of the Black Hills forest resources is not being used, and suggested a number of ways in which their use could be increased. During the business portion of the meeting, E. H. Stevens of the South Dakota School of Mines presented a report on the meeting of the Council of Section Delegates of AIME which he recently attended in New York.

Personals

Godfrey B. Walker, consulting mining and metallurgical engineer, has announced a change in his headquarters address to 33 Ballwood Rd., Old Greenwich, Conn. Prior to entering private consulting practice, Mr. Walker was associated for many years with American Cyanamid Co. At Cyanamid he was engaged in mineral dressing at the Research Laboratory in Stamford, Conn., and held the title of assistant director of mineral dressing.

G. B. WALKER

L. A. NOGALES

David D. Baker has been appointed director of the Production Evaluation Div. of the Grand Junction, Colo., office of the U. S. Atomic Energy Commission. Mr. Baker, who had been serving as deputy director since the formation of the AEC division in January, succeeds **Arthur E. Granger** who is now chief of the Salt Lake City branch of the division. Mr. Granger had requested a reassignment of duties for health reasons.

Harris W. Grose, general auditor for American Smelting and Refining Co., has been elected president of the Asarco 25-Year Club. He succeeds **H. F. Burroughs** who has served in the office for the past year. Mr. Grose has been with Asarco for almost 32 years.

R. F. Goodwin, chairman of the executive committee of Southern Peru Copper Corp., an Asarco subsidiary, was recently elected president of the Mining and Metallurgical Soc. of America.

Kenneth J. Butler, who has been associated with Colorado Fuel and Iron Corp. since 1946, has been appointed assistant sales manager of the springs and formed wire department of the Wickwire Spencer Steel Div. of the corporation.

Correction

Elliot Gillerman was incorrectly listed on p. 396 of the March issue as associate professor of geology at the University of Texas. Mr. Gillerman is associate professor of geology at the University of Kansas, Lawrence. He had been on the staff of the University of Texas before his new appointment.

Luis A. Nogales, consulting mining engineer of Bolivia, is at present in the Dominican Republic as chief of the Geophysical Exploration Dept. of the Cia. Dominicana, a subsidiary company of Barium Steel Corp. of New York.

John R. Mullen of Hidden Splendor Mining Co. has been transferred from the Delta Mine to the Far West Shaft. Mr. Mullen was mine superintendent at Delta, and holds the same position at the West Shaft.

C. G. Carlson, who had been a petroleum engineer for General Petroleum Corp., is now manager for the Yuba Mining Div., Yuba Consolidated Industries in California.

Anatol Glas, who had been chief engineer in the Research Dept. of American Smelting and Refining Co., has retired after 17 years of service with the company. During his career with Asarco, Mr. Glas has been concerned with mining, geology, and mineralogy.

DeForest S. Lewis, formerly vice president of Alkali Inc., is now president of Metal Assets Ltd., New York.

Two recent staff changes were announced by Allis-Chalmers Manufacturing Co., Milwaukee. **Arthur P. Hunter** has been named supervisor of cement machinery sales, succeeding **C. E. Burnett** who was recently named engineer-in-charge of pyroprocessing machinery.

David R. Cole, who was engineer for Idarado Mining Co., has been promoted to safety foreman.

Charles S. Anderson of Knott & Mielly Inc. has been field engineer for the installation of roadway and underpass lighting on the Calumet Skyway Toll Bridge. Prior to joining Knott & Mielly, Mr. Anderson was a junior engineer for Magnolia Petroleum Co.

H. Keith Conn, chief geologist in the exploration department, Canadian Johns-Manville Co. Ltd., has been promoted to exploration manager, succeeding **N. H. Hendry,** who has been appointed assistant sales and merchandising manager. Mr. Conn, a graduate of the University of Toronto in engineering and mining geology, joined Canadian Johns-Manville as a geologist in the exploration department in 1951. Later he was appointed assistant chief geologist and in 1953 promoted to chief geologist.

Robert G. LeTourneau, left, president of R. G. LeTourneau Inc., Longview, Texas, is shown receiving a Beaver Award from George H. Atkinson, president of The Beavers. Mr. LeTourneau, a world famous pioneer in the earthmoving business, received the award at the third annual awards dinner of The Beavers in Los Angeles for his leadership in the design and development of heavy equipment for the construction industry. Just completing a five-year absence from the earthmoving equipment business, Mr. LeTourneau has been engaged in building ultra-heavy duty equipment for such industries as logging, off-road transportation, heavy materials handling, offshore drilling, and land clearing.

Herman W. Ferguson, who had been geologist for the Tennessee Coal and Iron Div., U. S. Steel Corp., is now senior geologist for Michigan Limestone Div., U. S. Steel Corp.

Charles K. Burridge is now manager and partner in Burridge-Nyland Equipment Co., Ishpeming, Mich. Mr. Burridge, formerly field engineer for Hewitt-Robins Inc., formed the partnership with **Arvid A. Nyland,** an Ishpeming business man, and **Hugo H. Korpinen,** formerly general superintendent of underground properties for the Cleveland-Cliffs Iron Co., Michigan District. In the new firm Mr. Nyland manages the business end, Mr. Korpinen acts as a combination salesman and consultant, and Mr. Burridge manages the organization and acts as salesman. Also a member of the staff is **Samual J. Graham,** Ironwood, Mich., who is a salesman. Mr. Graham recently retired from Gardner-Denver Co., where he had been employed for 34 years.

Richard Wells, recently a geology student at Syracuse University, is now at the University of Michigan and is also associated with Chelsea Exploration Co.

H. V. Echols was appointed managing director of Indian Aluminium Co. Ltd. in January 1958. The firm, whose head office is located in Cal-

cutta, India, is a subsidiary of Aluminium Ltd. Mr. Echols joined the Aluminium Ltd. Group in 1942 and prior to his transfer to Indian Aluminium Co. was, successively, head of Aluminum Co. of Canada's mining department, managing director of Demerara Bauxite Co. in British Guiana, and since 1955 has been associated with the expansion of the Group's activities in the bauxite and alumina field on the staff of the director of operations in Montreal.

Erwin C. Winterhalder has accepted a position as geologist with Western Gold & Uranium Inc., St. George, Utah.

D. F. Coolbaugh was recently appointed as advisor in mineral technology by the Ford Foundation to be stationed in Burma. The position is being administered by Dunwoody Industrial Inst. for the Ford Foundation and Mr. Coolbaugh will make his headquarters at the Government Technical Inst. in Insein, Burma. Since his return in 1957 from Greenland where he was engaged in research work under contract to U. S. Army Corps of Engineers, he had been doing consulting work in mining and geology.

A. A. LEWIS

H. S. McCRAY

Albert A. Lewis, formerly associated with the Aluminum Co. of America, has been practicing consulting geology and mining engineering with an office in the Portland, Ore., area. His work has taken him into most of the western and southern states and during the last year and a half, he has spent a total of nine months in South America. He recently moved his office to the Los Angeles area and his address is 3303 Empty Saddle Rd., Rolling Hills, Calif.

Joe F. Krom is now vice president and general manager of Victory Mines Corp., Seattle. He had been president and general manager of Kromona Mines Corp. until the firm went out of business and their assets were acquired by Victory Mines.

Howard S. McCray has been elected chairman of the board and chief executive officer of Texas-Zinc Minerals Corp. and **A. L. Hayes** has been named president. The uranium exploration and mining company is jointly owned by the Texas Co. and the New Jersey Zinc Co.

Two assistant vice presidents have been named by U. S. Steel Corp.'s Production Dept. **Elwood B. Nelson,**

formerly general manager of the Coal Mining Div., was named assistant vice president, coal-production; and **Woods G. Talman,** general superintendent of the corporation's coal operations in the Gary, W. Va., and Lynch, Ky., districts, was appointed assistant vice president, coal-staff. Three administrative vice presidents have also been named by U. S. Steel. **James C. Gray,** vice president, Coal Div., is now administrative vice president—raw materials; **R. M. Lloyd,** vice president—raw materials, is now administrative vice president—international and raw materials-staff; and **M. D. Millard,** assistant vice president-sales of the American Steel and Wire Div., is now administrative vice president-international.

R. M. Wigglesworth is now a metallurgical research associate at Mackay School of Mines, University of Nevada, engaged in research on flotation of uranium ores. He had been a metallurgical consultant for Canadian Exploration Ltd.


L. J. PARKINSON


D. E. NEWTON

Allen Botsford is now engaged in private consulting in San Fernando, Calif. Since 1950 he has been a consultant in the U. S. Government programs of exploration, development, and production of scarce and strategic minerals for the Defense stockpile. During that time, Mr. Botsford's field had been western Europe, the Near East, and the continent of Africa, with headquarters in London, England.

Lute J. Parkinson, head of the department of mining engineering, Colorado School of Mines, spent two weeks in Mexico conferring with the mining engineering faculty of the University of Guanajuato and advising them on curriculum. Professor Parkinson also delivered a series of lectures at the University.

Roderick G. Murchison, who had been exploration manager for Tin and Associated Minerals Ltd., Jos, Nigeria, is now geologist with Kennecott Copper Corp., on the staff of the New York office. Tin and Associated Minerals is a subsidiary of Kennecott.

Norton Jackson is now assistant director of the Technical Services Div., Cyanamid Australia Pty. Ltd., Melbourne, Australia. He had been assistant superintendent of research and development for the South Australian Dept. of Mines.

Douglas E. Newton was recently appointed product manager for Western Machinery Co. in San Francisco. Mr. Newton has an extensive background in metallurgical engineering, including both field and sales experience.

Sherwin F. Kelly was a recent lecturer at the Explorers Club in New York. Mr. Kelly spoke on the *Bolivian Andes* and showed color motion pictures. He also demonstrated, by means of drawings, how geophysical exploratory work is carried on by his company.

Fred D. Kay, who had been vice president of International Titanium Corp. (Metal and Thermit Corp.), has set up an engineering consulting business and can be reached at Salisbury Point, South Nyack, N. Y.

W. W. Slade received his E.M. degree at the University of Illinois last

June. He is now with Owens-Illinois Co., Pacific Coast Div., and has been associated with that concern for twelve years. Mr. Slade's thesis for his degree was on *Glass Sand and the Ione Formation* and deals with the development and construction of the first successful specialty sands operation in the Ione formation in California.

H. M. Pickering has opened a mining consultant office at 302 E. 22nd St., Hibbing, Minn. Mr. Pickering recently retired as superintendent of heavy trucking for the Oliver Iron Mining Div., U. S. Steel Corp., on the Mesabi Range. He had spent 37 years in mining.

Lloyd J. Severson, formerly vice president of the Oliver Mining Div., U. S. Steel Corp., is now president of Quebec Cartier Mining Co., a U. S. Steel affiliate. He is a veteran of more than 20 years of mining experience in South America, Europe, and the U. S. Mr. Severson is a native of Wisconsin and a graduate mining engineer from the University of Wisconsin. He will now make his permanent residence in Montreal. He is also president of Hart-Jaune Power Co. and Cartier Railway Co.

Arthur G. Grenier, who had been a student at Stanford University in California, is now a junior engineer for Compania Minera Asarco S. A., Santa Barbara, Mexico.

John H. Lucas has been promoted from mine engineer and assistant quarry superintendent to quarry and crushing plant superintendent for Permanente Cement Co., Cushenbury Plant, Lucerne Valley, Calif.

N. Kentish is now employed by the La Luz Mines Ltd., Siuna Via Managua, Nicaragua, as mine superintendent.

Newly elected officers of the Perlite Inst. are: **D. Loring Marlett,** Great Lakes Carbon Corp., president; **Norman E. Braun,** Cleveland Gypsum Co. vice president; and **J. C. Kingsbury,** F. E. Schundler & Co. Inc., and **Theron L. Lehr,** Texas Lightweight Products Co., two-year directorships. Continuing as directors are **Frank Schaffer,** Perlite Products Co.; **O. Lewis Staerker,** Tennessee Products & Chemical Corp.; and **Lewis Williams,** Perlite Industries of Arizona Inc. **Lewis Lloyd,** Alatex Construction Service Inc., continues as advisor to the board of directors.

George E. Stringfellow, formerly vice president and division manager of the Storage Battery Div., Thomas A. Edison Industries, is now a vice president associated with the trade-relations interests of the Edison Industries. Associated with the storage battery operations for the past 30 years, Mr. Stringfellow is a director of Mine Safety Appliances Co., American Mining Congress, and Indiana Technical College.

personals

continued

John A. Sanford and **J. T. Brennan** have retired from Ingersoll-Rand Co., Salt Lake City, after a combined service of 78 years with the company. Mr. Brennan, a native of Butte, Mont., joined Ingersoll-Rand 36 years ago and has spent the past 25 years working out of the Salt Lake City office, particularly for mines in Utah and Eastern Nevada. Mr. Sanford, a graduate of Cornell University in 1916, went to work for Ingersoll-Rand at the Painted Post plant after graduation. Since that time he has held many positions of responsibility and has spent the past 15 years in Salt Lake City as office supervisor.

J. A. Kelley has been named president of Zonolite Co., Chicago, succeeding **J. B. Myers** who has resigned, but will continue as consultant to the company. Mr. Kelley, who joined Zonolite Co. in 1946 was made a vice president in 1953 and in 1956 was named executive vice president for the firm in charge of all plants and mines including the original vermiculite deposit at Libby, Mont. A graduate in mining engineering from the University of Pittsburgh, he had been associated with the U. S. Bureau of Mines and the War Production Board. During World War II, he served in the U. S. Navy.

Peter O. Sandvik, who had been engineer-assayer for the Territorial Dept. of Mines, Nome, Alaska, is now an instructor of geology at the School of Mines, University of Alaska, College, Alaska. He completed a year of graduate work in mining geology at Colorado School of Mines in June 1957 and during the summer worked as a geologist for Bear Creek Mining Co.

Wilfred A. Lyons is now resident geologist for Empresa Minera Pulacayo, Pulacayo, Bolivia, engaged in geological reconnaissance and study of copper and tin-silver mines for further exploration by diamond drilling. He had been assistant geologist for Compania Minera Aguilar S. A., Jujuy, Argentina.

Minerals Beneficiation

(Continued from page 616)

low pH. Further discussion ensued on the diameter size of pilot tailings lines and the pump velocity for which a 36-in. line was designed.

A squirrel-cage motor can be modified to provide the proper torque characteristics for starting a large conveyor belt, C. B. Risler reported. Comments from the floor emphasized the need for standardization of design torque motors. Special problems are encountered with variations in altitude, and most operators in such conditions have had to make adjustments for their motors. Mr. Risler commented that he thought one large motor was more efficient for driving a conveyor belt than a dual motor system.—*H. L. McNeill*

Magnetic Separation—This symposium on recent trends in equipment and applications was very well attended. A highlight of the paper covering cobbing separations by Wm. Aubrey was the colored movie which forcefully demonstrated some of the basic principles of a magnetic cobbing operation. In this movie, the nonmagnetic pieces were painted with red paint which resulted in very good delineation from the magnetic pieces of ore. Another phase of Aubrey's paper which raised considerable comment was the recommendation that the buyer of a magnetic separator should insist on specified field strength. This can be obtained from manufacturers in the form of a plot of gauss meter readings. Examples of such plots were shown by the author.

The use of wet magnetic separators specifically designed for use in the heavy media process evoked interested discussion from the audience. One special magnetic separator which consisted of drum separators mounted in a spiral classifier tank was described. This unit it was claimed overcomes many of the disadvantages of conventional-type magnetic separators.

A paper covering magnetic separation of taconite described some of the problems of magnetic separator drum covers. The relative merits of stainless steel covers vs rubber ones was the subject of debate from the audience.

A description of and comment on recent developments in dry magnetic separation inspired considerable attention from the audience. The demands for extremely high purity iron ore concentrates by the reviving sponge iron industry has forced new attention on dry magnetic separation methods. The problems associated with dry magnetic separation of ores finer than 325 mesh are under attack by several research laboratories. It seems apparent that no one separator will process an extremely wide range of particle sizes. Special separators are being designed for selected size ranges.—*L. A. Roe*

Pyrolyis and Agglomeration—This joint session with the Iron and Steel Division of The Metallurgical Society was devoted largely to a presentation of papers describing various aspects of the R-N process for the direct reduction of iron ore. Alex Stewart, president of the R-N Corp., gave a brief account of the development of the process and the reason for the joint undertaking by Republic Steel Corp. and National Lead Co. The general details of the process were described by H. K. Work who outlined the process and gave the results of continuous test runs made at Birmingham. In that plant more than 100,000 tons of ore have been processed, and depending on the grade, concentrates in the range of 95 pct total iron with 90 pct or better metallic iron and with less than 2 to 3 pct silica, have been produced with an overall iron recovery of 85 to 90 pct.

Mr. Babcock gave the results of extensive reduction tests carried on in electric furnaces at the Chicago plant of the Republic Steel Co. These tests showed the briquetted material to be a satisfactory melting stock.

Mr. Herasymenko from New York University gave figures on what could be accomplished in the way of ejecting sulfur and phosphorus from ores. Mr. Reed reported on the treatment of iron ores containing titanium, manganese, chromium, and alkali metal sulfates. Much of this work was done in Norway by a subsidiary company. This work indicated that such ores can be satisfactorily reduced.

The audience was impressed by the optimism and enthusiasm of the people presenting papers on this subject.—*F. D. DeVaney*

Solution and Precipitation—The session (joint with Extractive Metallurgy Division of The Metallurgical Society) covered the full range of process development in the uranium and vanadium field from an operating mill back to early laboratory work.

G. T. Bator described the operating plant and minor problems at the Mines Development Inc. Resin-in-Pulp plant at Edgemont, S. D. This features a *merry-go-round* which distributes the various solutions and slurries to the 14 banks of RIP baskets without many valves.

R. E. Musgrove described the pilot plant results on solvent extraction and recovery of vanadium from the Climax Uranium Co. solutions to obtain a higher grade product than is now being produced at their plant. The phosphate extractant gave a 92 pct V_2O_5 product. The amine solvent gave difficulties but produced a 97 pct V_2O_5 product.

M. E. Grimes of Eldorado described their pilot plant amine extraction of uranium from the Port Radium leach liquor. Magnesia stripping was economically desirable (because all reagents have 8¢ to 10¢ per lb freight cost way up there) but it gave some trouble. It is planned to start the full-scale plant using so-

dium carbonate stripping which requires more pounds of reagents but which gave trouble-free operation in the pilot plant.

Ray Long of Dow described three types of processes still under laboratory development: 1) leaching high lime ores directly with the organic solvent saves 90 pct of the acid cost. 2) Extracting slurries saves filtration costs, but presents an entrainment problem which is being combatted by wetting agents. 3) If the final solution from present ion exchange or solvent extraction plants is not precipitated to yellow cake but is treated by an extra stage or two of solvent extraction, a UF_4 product of promising purity is obtained. This may develop so that the larger mills can bypass the refinery. —*John Dasher*

Developments in Operating Control—Five papers covering general developments in operating control were presented. Of particular interest were the discussions of gamma ray gages and hydraulic measurement. H. B. Graves, Jr., and Elliott Northcott told about the development of a continuous BPL analyzer. Two papers covered weighing of solids—Thomas Mell presented material on automatic weighing and ratioing while T. P. Goslin discussed developments in continuous weighing of bulk solids. Hydraulic solids flow metering was the topic presented by E. J. Klein and E. F. Nagle. John R. Reide presented data on the use of gamma ray gages in beneficiation plants.—*J. Walter Snavely*

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means to expand the production of limestone from a privately owned and operated property in India.—*W. Rundle* and *H. J. Schwellenbach*

Safety and Health (Mining)—*Preplanning Safety in the Uranium Industry*, prepared by John E. Bailey, National Lead Co., and presented by Brower Dellinger of the same company, emphasized that, in addition to the normal hazards attendant to underground mining, radiation dangers from radon gas are present. That the uranium industry, not only in mining operations but in processing operations, has been alert is shown by statitistics that reveal that normal accident hazards are the causes, not those due to radon.

E. A. Barry of Mine Safety Appliances Co. described what communication, television, and tone control can accomplish. There are five groupings where such equipment is adaptable: 1) safety, 2) central control, 3) quality control, 4) cost reduction, and 5) visual control. Demonstration equipment showed wide flexibility and many functional data that are obtainable. Applications of such equipment are limited only by the imagination.

The *Symposium on Safety and Health* emphasized the need for close cooperation between government, labor, and management. Mr. Slouman presented Mr. Westerfield's paper describing USBM services. The paper listed the many Bureau functions and services and emphasized the value of these to the mining industry. Dr. Calley presented Mr. Doyle's paper on the role of public health service in mine safety. Studies of silicosis for radiation were cited. Mr. Johnson described USBM training in first-aid and accident prevention. Results of the training cannot be over emphasized.

Mr. Romney summarized the symposium using the experiences of the Utah Industrial Commission as an example of cooperative effort between government, labor, and management.—*J. M. Ehrhorn* and *M. P. Romney*

General Mining—The session started with a very interesting panel discussion on blasting with ammonium nitrate. Charlie Grant of Jones & Laughlin's Minnesota Ore Div. explained ammonium nitrate blasting

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practice on the Mesabi range. Of interest were his comments on—first, unsuccessful and then successful—shots using 400-grain Primacord as a detonator. A. C. Bigley related Anaconda Copper's experience with ammonium nitrate in its various open pit mines. L. J. Patterson described Michigan Limestone's specially designed truck for loading ammonium nitrate into holes while mixing with oil through a pressurized automatically metered spray system. Walt Chapman of National Lead's MacIntyre Development told of shooting water-filled holes using free-running ammonium nitrate. The discussion was animated and highly interesting and certainly revealed that many miners are interested in using ammonium nitrate to the fullest extent possible, and are working to solve the problem of applying nitrate to wet holes.

A two-paper panel on the use of conveyors underground was presented by B. R. Coil speaking of Miami Copper's underground belts and Howard Graff who told of Inland Steel's belt installation at its Sherwood mine. Both papers showed that, when properly installed, underground conveyors can substantially assist the mine operator in cutting transportation costs underground. The final paper by John Wangaard described raising by use of a cage in a Pickands Mather iron mine in Michigan. After describing the increase in raising speed through improved efficiency and the excellent safety situation, John spent considerable time answering questions in a discussion session.—*Hugh J. Leach*

General Mining—Four topics were covered on this Thursday morning session: research, economics, blasting, and drilling. Leonard Obert gave a review of mining research in Europe. John A. Patterson presented a study of statistical methods of analyzing the variations in ore reserves, mining costs, and profits with variations in cutoff grade. Such methods enable the mine operator to select the cutoff which will return the maximum profit. He described methods applied to each variation.

A unique feature in terms of presentation was that given by Lewis D. Leet. His *paper* was a film on blasting vibrations, their cause and effect, and a question-answer period followed.

Howard L. Hartman discussed fundamental studies of percussion drilling. After summarizing the tests of rock penetration under impact, he was able to draw a number of conclusions generally applicable to percussion drilling: 1) The wedge seems to be the most desirable bit shape. 2) Blow energy needs to be high, 3) blow velocity low, and 4) blow transfer helpful especially when the old *piston-drill* principle is applied. 5) Blow indexing is critical, but not as much so as was once thought, and the index distance to insure 100 pct indexing with sharp wedges is almost prohibitively small. 6) Power is even more critical than energy in percussive drilling.

Canadian-Latin American Session (Mining)—The Bicroft Uranium Mines operation, a new mine located in the uranium-bearing pegmatites of the Bancroft area in southeastern Toronto, was described in a paper by John M. Thompson. The ore occurs in relatively small lenses in a zone 3000 ft long but with excellent vertical continuity. Close control of the primary mine ore grade is obtained by using Geiger counters to outline the limits of the ore to be broken. The operation mines and treats 1200 tpd in an acid leach CCD plant using ion exchange with an average recovery of 93 pct.

A. E. Moss, chief engineer of the Iron Ore Co. of Canada, gave a very interesting paper on the discovery and development of iron ore deposits in northeastern Canada near the center of the Labrador Peninsula and described open pit mining operations under severe mid-winter

conditions. Production, which began in mid-summer 1954, has steadily increased; during 1957 13,000,000 long tons were shipped. Shipments must meet rigid physical and chemical specifications. A wide range of ores are being mined which require a high degree of planning, scheduling, and close grade control during mining to meet required specifications. Ore is hauled by railroad a distance of 360 miles to tidewater at Seven Islands where it is shipped by water to its destination.

A paper on the new Moa Bay-Port Nickel Project, a new free world source of nickel and cobalt from Cuban ores, was excellently presented by Forbes K. Wilson, vice president, Freeport Sulphur Co. About 50,000,000 tons averaging 1.36 pct Ni, 0.13 pct Co, and 46 pct Fe have been developed and are sufficient to support an operation with an assured life of 20 to 25 years. Production is scheduled to begin in mid-1959 at a rate of 50,000,000 lb Ni and 4,400,000 lb Co annually. The mining method is unique in that the ore as mined at Moa Bay occurs in nature in sizes of about 90 pct −325 mesh. After screening out all +20 mesh material, the ore is transported 14,000 ft by gravity through a 24-in. pipeline in a slurry containing about 35 pct solids. The processing plant at Moa Bay will produce a Ni-Co sulfide concentrate which will be transported in slurry form to the refinery at Port Nickel, La., in a specially designed cargo vessel. This ship is designed for shuttle service between Moa Bay, Cuba, and Port Nickel, La., and on its return trip will carry a cargo of molten sulfur and liquid petroleum gas in special tanks and containers.

A paper describing a unique method of shrinkage stoping using long sash drill jumbos and small air-powered bulldozer equipment at Eagle-Picher's Esmeralda Unit, Parral, Mexico, was given by R. B. Taylor. Conventional shrinkage stope breakage was increased by almost 600 pct in the wider stopes with high labor efficiency and low powder factor. Interesting production and cost figures were given. The Esmeralda Mine operation has taken full advantage of mechanization and has achieved operating efficiencies which are high by any standard of comparison.—*John W. Chandler*

Selected Geologic Topics—The topics covered on this session ranged geographically from New Mexico to the Mississippi Valley and in scope from the specific to the theoretical. Charles B. Belt, Jr., in his paper on intrusions and ore deposition in New Mexico, gave a brief resume of the theory that hydrothermal ore deposits are precipitated from solutions of fluids that had been separated from deep-seated magmas. Originally this theory was based on the dubious evidence of an areal relation between intrusion and ore deposition. In order to test the theory, several New Mexico ore deposits were tested and specifically, primary petrology, alteration, and distribution of the copper and zinc in silicic plutons were studied in relation to nearby hydrothermal ore deposits. Results indicated that the ore deposits did not originate from the adjacent intrusives and are not genetically related in the sense of the theory being tested.

A second study on origins of ore deposits was given in Ernest Ohle's paper on the Mississippi Valley-type deposits. He presented a review of the main features of this type and gave an analysis of the theories that have been proposed for origin.

The last three papess on the session were theoretical in nature. Hugh McKinstry discussed the number of minerals occurring together in equilibrium in relation to the requirements of the Phase Rule. Diagrams inferred from many records of natural occurrences were presented.

Sulfide systems as geological thermometers was the topic covered by Gunnar Kullerud. Pointing out that

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there were only two methods sufficiently tested to ensure their proper application, he went on to describe them and show their proper use, separately and in combination. Summarizing, Mr. Kullerud pointed out that results indicate that temperature gradients existed during ore formation.

R. J. P. Lyon applied time aspects of geothermometry to specific ores. Diffusion experiments, in spite of possible unsuspected variables, indicated time spans.

Copper Mineralization and Regional Structure in Arizona, New Mexico, and Sonora (Geology)—A lively symposium on relations of mineralization, particularly copper mineralization, to regional tectonics in southwestern United States and northern Mexico served to confirm some old ideas, raise doubts as to others, and stimulate some possible new lines of thought.

S. E. Jerome and D. R. Cook in a comprehensive study recognized the importance of repeated tectonic activity in maintaining deeply penetrating *plumbing* systems that supplied channels for escape of magmas and metals from deep in the crust. They emphasized the importance of the northeast trending (pre-Cambrian) structures, and the close relationships of ore districts to true magnetic activity. C. J. Sullivan declared that the same data could be interpreted as a case for origin by granitization.

A paper by Evans B. Mayo recognized a great number of structural trends related to lineament structures and dominated by the *Texas lineament*. Trend intersections yield favorable loci for granitic intrusives, volcanic activity, and ore districts. Of the intersections, 18 of 19 considered as *first class* contain major ore districts; 10 of 13 intersections considered as *second class* have yielded ore districts. Vincent Kelley noted that the term *lineaments* should be restricted and the trends should be designated as *format* lines which serve as *thinking lines* for guiding exploration. Both C. Behre and S. E. Jerome pointed out necessity for considering the element of time.

A thought-provoking paper by Harrison Schmitt emphasized the fundamental control of the *Texas* and *Jerome* lineaments in localization of geosynlines, intrusives, and mineral districts in the southwest since pre-Cambrian times. These three are related to the lineament rather than to each other. He suggests unusually deep foundering of the crust in the area of the *copper oval* of the southwest at the intersection of the Texas and Jerome lineament caused penetration of the *chalcosphere* producing the copper province. Seawaters penetrating along lineament breaks aided mobilization of metal values with or without accompanying igneous activity.

John W. Gableman described effective utilization of colored aerial photos in mapping alteration zones which permitted rapid delimitation of tectonic elements. He emphasized, likewise, the correlation of mineral belts with tectonic intersections.—*W. C. Lacy*

Geology of Titanium Deposits—The symposium was under the sponsorship of IndMD, Geology, and SEG. Of the three papers having to do with geological occurrence, one reported on the massive in-rock deposit at Lac Tio, Que., and the other two described detrital deposits in India and New Jersey. A fourth paper had to do with the evaluation of detrital deposits. The session closed with Louis Moyd's colored slides and commentary regarding detrital ilmenite deposits along the coast of eastern Australia and West Africa. Attendance was good, the audience attentive, the papers well presented, and the discussion informative.

While the presentations were mostly of a factual nature, genesis was not neglected. Competing concepts as to the origin of the Lac Tio deposit were reiterated and not resolved. Notable conversions were nil. Disagreement was not expressed as to processes credited with the production of detrital occurrences.

The striking difference in character of the minerals intergrown with ilmenite in detrital deposits as contrasted with the hematite-ilmenite intergrowth in the Lac Tio deposit was well exemplified. The question as to whether or not massive deposits of hematite-ilmenite or of magnetite-ilmenite have substantial detrital derivatives was not discussed.

The most significant fact disclosed by this symposium is the existence in many parts of the world of a great deal of titanium in easily accessible detrital deposits of ilmenite amenable to well established methods of concentration, the utilization of which is primarily dependent on economic factors and to a lesser extent on political factors.—*William H. Callahan*

Geophysics General Session—Although competition from the weather, i.e., the East's heavy snowfall, made attendance uncertain on the first days of the meeting, the session drew over 60 and the six papers scheduled drew considerable questions and discussion. Sherwin F. Kelly presented data on spontaneous polarization as applied in prospecting for nonconductive stibnite. Some case history material was covered in the study of the Clearwater, N. B., deposit related by H. W. Fleming and R. R. Brooks and in R. W. Baldwin and associates' account of the work by Newmont Exploration Ltd. in geophysical application and overvoltage developments from 1946 to 1955. The role of soil was covered generally and specifically, with a summary of the significance of geochemical distribution trends in soil by D. H. Yardley and the effects of soil contamination on geochemical prospecting in the Coeur d'Alenes by F. C. Canney. The quantitative aspects of aeromagnetic interpretation were explained by D. W. Smellie.—*B. F. Howell, Jr.*

New Exploration Techniques (Geophysics)—An excellent attendance of over 130 and considerable discussion from the floor pointed up the considerable interest in future sessions on exploration techniques with emphasis on operating procedures and case histories. The five papers given covered the more recent developments in geochemical prospecting field methods. In general the material leaned strongly to practical or application-type data with minor case history-type information accompanying the presentations. The final discussions of the session took the form of an open forum during which foreign developments and general field problems were report-

ed. The information covered and the ensuing discussions showed the continuing need for further field analytical methods that are applicable to special problems. Such methods should be of an encompassing nature including other elements rather than specifically limited.—*G. E. Manger* and *M. E. Tripp*

New Exploration Techniques (Geophysics)—Although the session on new geophysical methods of mineral exploration was held on the last half of the last day of the meeting, it was attended by an average of 60 right up to the bitter end. An innovation was tried in the form of an open discussion on new techniques at the end of the formal program, at which time members of the audience contributed tidbits of information on unpublished research and development. The success of this may be indicated by the fact that nobody left the room until 5:40. Four papers were presented by members of the U. S. Geological Survey on results of geophysical research supported by the Atomic Energy Commission. Hans Lundberg of Toronto pulled the veil a little further back on his airborne gravity gradiometer, and an extremely significant paper on the cause of the self-potential effect near oxidizing sulfide deposits was presented by Motoaki Sato, working under Professor Mooney at the University of Minnesota.—*H. E. Hawkes, Jr.*

Obituaries

Leon L. Larche, Jr. (Member 1956), was killed in a mining accident on Dec. 30, 1957. Mr. Larche, who was born in Eureka, Calif., in 1929, had attended Mackay School of Mines, University of Nevada. Prior to a three-year enlistment in the Marine Corps, Mr. Larche attended the New Mexico Inst. of Mining & Technology. Later he worked as miner for The Anaconda Co. in Butte, Mont. He enrolled at the Mackay School of Mines in February, 1955. During his summer vacations, Mr. Larche worked for various concerns, among which were Pacific Islands Trading Co., San Francisco; Bunker Hill & Sullivan Co., Kellogg, Idaho; and U.S. Forest Service, Placerville, Calif.

Joseph V. Mather (Member 1940), died in Philadelphia on May 15, 1957. Born in Cranberry, W. Va., in 1908, Mr. Mather spent the major part of his career in the coal mining areas of West Virginia and Pennsylvania and one of his early associations was with Carter Coal Co., formerly Consolidation Coal Co., as draftsman, transitman, and rodman. Mr. Mather then became assistant foreman in charge of ventilation and construction, before leaving to join Premier Pocahontas Collieries Co., Premier, W. Va., as chief engineer. He was later a member of the staff of the U.S. Bureau of Mines, Wilkes-Barre, Pa., engaged in mining and explosive engineering.

James D. Mooney (Member 1912), a former vice president of General Motors Corp. and president and chairman of the board of Willys-Overland Motors Inc., died on Sept. 21, 1957. Born in Cleveland in 1884, Mr. Mooney got his training as a mining engineer at the Case School of Applied Science in Cleveland. After brief periods with mining companies in Mexico and California, he gained experience as a technical writer with Westinghouse Electric Co. and *American Machinist*. Mr. Mooney's association with the automotive industry began in the 1920's after he had been a sales engineer-conveyors for B. F. Goodrich Co. In 1922 he became general manager of the General Motors Export Co., and in 1928 president of that company. During the 1940's Mr. Mooney rose to the vice presidency of General Motors and the board chairmanship of Willys-Overland. Four years ago he opened his own organization, J. D. Mooney Associates, with offices in New York.

John J. Oberbillig (Member 1924), president of United Mercury Mines, Boise, Idaho, died in San Francisco in January 1958, while in that city on business. Born in Milwaukee in

1878, Mr. Oberbillig, mining pioneer, prospected in Alaska and Idaho at the turn of the century, and later ran a laboratory in Idaho where he did research and commercial assaying. In 1918 he became the general manager of ten mining companies in the Idaho area. Three years later the companies were merged into one, the United Mercury Mines Co., and Mr. Oberbillig became president, a position he held at the time of his death. He had also been president and general manager of Reliance Gold Co.

Necrology

Date Elected	Name	Date of Death
1916	L. M. Allen, Jr.	Feb. 12, 1957
1923	Walter S. Bourlier	December 1957
1955	Jack E. Chiesler	November 1957
1947	Edward J. Fearing	Feb. 18, 1958
1919	Wilbur H. Grant	Dec. 28, 1957
1953	W. Sturgis Macomber	Aug. 1, 1957
1918	Fred H. Moffit	Unknown
1914	Charles Raymond Stahl	Dec. 24, 1957
1909	Clinton M. Young	Oct. 14, 1957

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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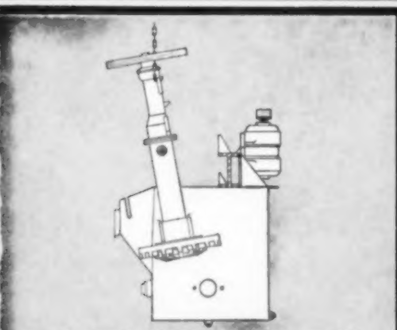

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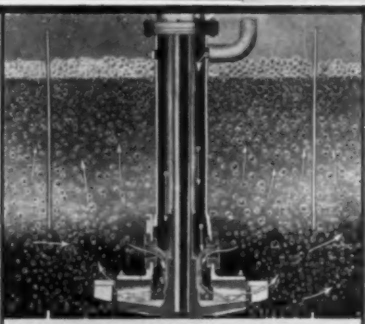

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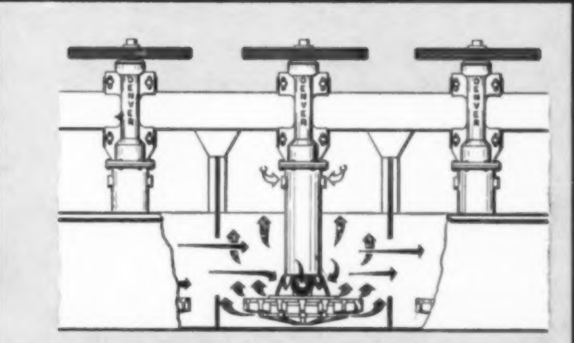

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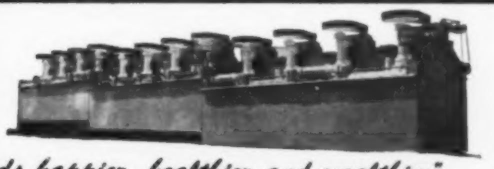

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